3420
Report No. R4-92-01

A BIOLOGICAL EVALUATION OF THE DOUGLAS-FIR TUSSOCK MOTH OUTBREAK IN SOUTHERN IDAHO, 1991

Julie C. Weatherby[1]
K. Andrew Knapp[2]
Brian R. Gardner[3]
Joy Roberts[4]
Phil Mocettini[5]

ABSTRACT

In 1990, Douglas-fir tussock moth activity was detected in southern Idaho for the first time since 1983. Conifers on 39,499 acres were defoliated. Aerial surveys in 1991 detected approximately 312,000 acres of conifer defoliation resulting from Douglas-fir tussock moth activity on the Boise, Payette, and Sawtooth National Forests; and Bureau of Land Management and State lands east of Bellevue and in the Owyhee Mountains. This is the largest Douglas-fir tussock moth outbreak ever recorded in southern Idaho.

Ground survey data indicate that tree mortality in the most heavily defoliated stands could average as high as 73.0 and 42.6 trees per acre in the Sagehen/Squaw Creek and Boise River infestations, respectively. In addition, abundant top-kill of surviving trees is expected.

Some geographical areas of concern which have not previously sustained defoliation include Sunset Mountain, Boise National Forest; and Bald Mountain, Sawtooth National Forest and Bureau of Land Management. The results of lower crown cocoon sampling in 1991 indicate that 1992 populations could reach outbreak status in these areas.

---

[1] Entomologist, Forest Pest Management, Intermountain Region, USDA Forest Service.
[2] Biological Technician, Forest Pest Management, Intermountain Region, USDA Forest Service.
[3] Biological Technician, Forest Pest Management, Intermountain Region, USDA Forest Service.
[4] Computer Analyst, Forest Pest Management, Intermountain Region, USDA Forest Service.
[5] Biological Technician, Forest Pest Management, Intermountain Region, USDA Forest Service.

INTRODUCTION

The Douglas-fir tussock moth, *Orgyia pseudotsugata* McDunnough (DFTM), is a serious defoliator of Douglas-fir and true firs in western North America. Populations cycle periodically, rapidly increasing from endemic to outbreak levels. Outbreak cycles usually last 3 to 4 years before the population collapses as a result of a combination of mortality factors, including parasites, predators, diseases, and starvation.

Tussock moth populations overwinter in the egg stage. Egg hatch occurs after bud break in late May or early June. Small larvae disperse from egg masses redistributing themselves throughout the forest canopy. Long distance dispersal is accomplished when small larvae spin down from branches and are passively blown by winds. Such dispersal is usually limited to a distance of approximately 1/4 mile (Wickman et al. 1981).

Larval stages feed first on new foliage and move to older foliage after the new foliage has been consumed. When populations are extremely dense, trees can be almost completely defoliated in 1 year. Larval feeding occurs over a period of 40 to 60 days. Full-grown larvae seek out pupation sites during late July or August. Pupal cocoons are usually found on the undersides of branches; however, when populations are extremely dense, increasing numbers of larvae seek out other pupation sites such as tree trunks, rocks, fence posts, etc. Pupal cocoons consist of grayish, silken coverings each surrounding a single pupa.

Male moths begin emerging from pupal cocoons in August followed by the emergence of female moths. Male moths are gray-brown to black-brown with a wingspan of approximately 1 inch. Large, plumose antennae are conspicuous. Female moths are flightless and remain on or near their pupal cocoons for the duration of their lifespan. Females produce a pheromone which attracts males for the purpose of mating. Oviposition of eggs occurs directly on top of the pupal cocoon from which the female emerged. An average egg mass contains 150 to 200 eggs.

Feeding by DFTM results in varying degrees of defoliation. Light defoliation can cause top-kill and growth reductions. Heavy defoliation may culminate in tree mortality. As an example, approximately 39 percent of all trees in heavily defoliated areas in the Blue Mountains of Washington and Oregon were killed during the 1972-73 DFTM outbreak (Wickman 1978). Similar outbreaks have occurred in California, Idaho, Nevada, Arizona, New Mexico, and British Columbia.

In southern Idaho, periodic outbreaks have occurred. Tunnock et al. (1985) documented the occurrence of several DFTM outbreaks between 1927 and 1984. Despite these repeated outbreaks, vegetation impacts in these areas have not been well documented.

This report documents the results of the 1991 early warning system, special aerial detection surveys and subsequent ground surveys designed to estimate levels of defoliation and to predict impacts and trends in DFTM population densities. Population, defoliation, and impact projections are presented for 1992 along with a brief discussion of management alternatives for dealing with outbreaks.

EARLY WARNING SYSTEM

Methods: The early warning system is designed to detect population increases 1 to 2 years prior to an outbreak and has been used continuously in southern Idaho since 1982. This system

involves deployment of five pheromone-baited traps at each site, following the procedures outlined by Daterman et al. (1979), to detect and monitor male moths. "An average trap catch of 25 moths or more can indicate that the local population is approaching the outbreak stage" (Daterman et al. 1979).

In southern Idaho, trap catch data from 1982 to 1990 exist for 21 permanent sampling sites (Weatherby et al. 1991); therefore, these sites with the exception of two sites on the Salmon National Forest, one site on the Boise National Forest, one site on the Payette National Forest, and one site on State land were again used as sampling sites for 1991. Seventy-eight additional sites were added on the Boise and the Payette National Forests in order to monitor expansion of the current outbreak and to improve predictability of the early warning system during future outbreaks. The number of male moths captured within each trap was recorded, and the mean moth catch per trap was calculated for each site.

For the past 4 years, we have evaluated an additional monitoring method developed cooperatively by the USDA Forest Service, Region 5, Forest Pest Management and the University of California at Berkeley, CA, to sample the population seeking pupation sites. This method involves selecting 10 host trees within each trapping site and nailing two cryptic shelters to opposite sides of the bole of each tree. Twelve of the pheromone trapping sites were monitored using this sampling method. Data collected included the total number of pupae per shelter, their sex, and the condition of each pupae—either healthy, parasitized, or dead from unknown causes.

Results: Annual mean trap catches for the 21 historical sites are listed in Table 1 (See Table 2 for site locations and sampling dates.). In 1991, only 16 of these sites were trapped; trap catches decreased at all sites with the exception of two sites on Bureau of Land Management (BLM) lands in the Owyhee Mountains, and one site on the Sawtooth National Forest. This decrease probably occurred as a result of competitive interaction between artificial lures and female moths whose natural scent is more attractive to males than the lures used in this survey (Sower, per. comm.[6]). The average male moth catch per trap for the 16 sites monitored in 1991 was 39.9 moths. At 10 of the 16 sites, trap catches exceeded the 25-moth threshold.

Annual mean trap catches, site locations, and sampling dates for the 78 additional sites and the 21 historical sites are listed in Table 2. The average male moth catch per trap for all sites monitored in 1991 (including the historical sites) was 27.3 moths. The results of the overall 1991 trapping program have been grouped by infestation areas. Four major areas of infestation were identified as follows: the Boise River infestation, the Sagehen/Squaw Creek infestation, the Owyhee Mountain infestation, and the Mann Creek/Brownlee Creek infestation. The average male moth catch per trap in these areas was 72.2, 36.2, 76.1, and 23.2, respectively (Table 3). Conifers in several drainages east of Hailey and Bellevue were identified as a fifth infestation but trapping was not conducted in these areas. The mean trap catch for lightly and non-defoliated stands outside of the previously described infestation areas averaged 12.3 male moths per trap.

The 1991 cryptic shelter data are summarized in Table 4. Pupal cocoons were found in some of the cryptic shelters on 10 of the 12 sites. The mean number of pupal cocoons averaged for all monitored sites was 3.30 cocoons per shelter. The ratio of male to female cocoons was approximately 6.94:1.00 (Table 5) or two times the ratio reported in 1990.

---

[6] Research Entomologist, Pacific Northwest Experiment Station, USDA Forest Service.

AERIAL DETECTION SURVEY

Methods: Special aerial detection surveys were conducted during August in order to more accurately delineate defoliated areas. Areas of defoliation were sketch mapped by defoliation intensity. This information was digitized and plotted on 1/2-inch to the mile forest maps. Defoliation intensities were assigned based upon the proportion of the entire crown displaying visible feeding damage. Lightly defoliated areas were designated when the majority of the trees had visible feeding damage on less than 25 percent of the entire crown. Moderately defoliated areas were designated when visible feeding damage occurred on more than 24 percent but less than 75 percent of the entire crown. Heavily defoliated areas were designated when visible damage occurred on more than 74 percent of the entire crown. Due to stand age, composition, and site factors, areas being defoliated and defoliation intensity are often "patchy" (intermingled with non-defoliated areas) in occurrence. It was virtually impossible to accurately plot individual patches of like defoliation intensity. Instead, nearby pockets of defoliation with like intensities were combined into larger polygons.

Results: Approximately 312,000 acres of defoliation were mapped during special DFTM aerial surveys on the Boise, Payette, and Sawtooth National Forests and on State and BLM lands. Twenty-four percent of the total area (75,100 ac) was classified as lightly defoliated, 21 percent (64,300 ac) as moderately defoliated, and 55 percent (172,600 ac) as heavily defoliated. The areas of heaviest defoliation were located within the Boise River drainages on the Boise and Mountain Home Ranger Districts, Boise National Forest, and on the Fairfield Ranger District, Sawtooth National Forest; within the Sagehen/Squaw Creek drainages on the Emmett Ranger District, Boise National Forest; within the Mann Creek/Brownlee Creek drainages on the Weiser Ranger District, Payette National Forest; within the Owyhee Mountains on lands of mixed ownerships; and within several drainages east of the towns of Hailey and Bellevue, also on lands of mixed ownership. Figures 1 through 5 are copies of aerial sketch maps showing the location and intensity of detected DFTM defoliation. Defoliated areas have been extensively "ground truthed;" and, in all but one case, the major defoliator was DFTM. On the Weiser Ranger District, DFTM was found in conjunction with western spruce budworm (WSBW).

The 312,000 acres of defoliation detected in 1991 is an increase of approximately 272,600 acres over the acreage defoliated in 1990. Many of the areas reported to have received minor defoliation in 1990 where severely defoliated in 1991. This is the largest DFTM outbreak ever recorded in southern Idaho.

GROUND SURVEYS

Methods: In the summer of 1991, Forest Supervisors of the Boise, Payette, and Sawtooth National Forests were asked to identify areas they would like to have ground surveyed to obtain information concerning DFTM populations, individual tree defoliation, etc., with which to predict population trends and fate of affected trees. Many of the identified areas were located within the present outbreak boundaries as drawn from aerial detection surveys. Some areas outside of the present outbreak boundaries were suggested because they were composed predominantly of host type and had high resource values.

Boundaries of the areas to be surveyed were drawn on USGS 7.5 minute quadrangle maps. The

survey design involved collecting information from a series of five plots located along a transect. The number of transects to be sampled in each area was arbitrarily selected based upon the availability of personnel needed to complete the sampling before access was limited by snowfall. In the field, the actual location of each transect was selected based on road access, elevation, presence of defoliation and/or stand composition. No attempt was made to randomize transect or plot locations or to systematically cover the broad geographical areas. Rather, transects were selected and plots installed in order to obtain information about localized areas of defoliation and individual tree conditions.

The following sampling scheme was utilized. In areas with obvious defoliation, a five-plot transect was permanently installed. The first plot was located 2 chains from the road, and the remaining four plots were spaced 3 chains apart along a line which contoured the slope. Data were collected from a 40 BAF variable plot and a 1/300 acre fixed plot around each plot center. The center of the plot was located, and each tree within the variable plot was numbered. At each plot, site and individual tree data were collected. Site data included elevation, slope, aspect, habitat type, and physiographic site. Tree data included species, d.b.h., age, 5- and 10-year radial growth, cover class, and the occurrence of other pests. In addition, defoliation ratings in percent of total needle complement missing as a result of defoliating insect activity were visually estimated and recorded. On each plot, two 1991 egg masses were removed using sterilized forceps, each from a different tree, and placed individually in a zip-locked bag. These egg masses were taken to the lab for further evaluation.

In areas with no or very light defoliation, the sampling scheme also consisted of a five-plot transect. However, in this case, plots were not permanently installed. At the first and the fourth plots, the same site and individual tree data as identified above were collected. At each of the five plots, population sampling was attempted. Twenty host trees with lower crown branches within reach of the surveyor were selected for DFTM population evaluation. One 18-inch branch tip from each of three lower crown branches on each sample tree was visually inspected for the presence of pupal cocoons. Population sampling was not attempted in more heavily defoliated plots, because the distribution of cocoons throughout the tree canopy was concentrated nearer to the bole. Finally, two 1991 egg masses were removed from each plot for further evaluation as indicated for defoliation transects.

Egg masses collected from both the defoliated and non-defoliated areas were taken to the laboratory where they were transferred to paper envelopes and placed in an incubator set at 33°F. Egg masses remained in the incubator for 1 month before being removed, cleaned of extraneous material, and weighed. Each egg mass was returned to its envelope after weighing and placed back in the incubator for a 4-month cold period. In February, egg masses will be removed from the incubator and held at room temperature until egg hatch. The total number of eggs within each egg mass and the number of larvae which successfully eclose from the egg mass will be counted and recorded. Each larvae will be placed on artifical diet for rearing. Rates of parasitism and viral infection will be calculated.

Data manipulations and analysis: Plot data gathered from each transect were evaluated via INDIDS (Bousfield et al. 1985) to describe average composition, stocking, structure, and defoliation levels for three size classes of trees; 5.0" - 8.9", 9.0" - 11.9", and >12" d.b.h. within each transect area. Individual tree defoliation ratings (percent of needles missing) were grouped into five classes: non-defoliated, lightly defoliated (L = >0 but <25 percent), moderately defoliated (M = >24 but <75 percent), heavily defoliated (H = >74 but <90 percent), and very heavily defoliated (VH =

>89 percent). This defoliation rating information was used to develop an area damage index. The area damage index was calculated by multiplying the proportion of the stocking in each of the five defoliation rating classes by a weighting factor of 4, 3, 2, or 1 for the very heavy, heavy, moderate, and light defoliation classes; and then summing the products to arrive at the area damage index. The range of area damage indices (0.00 - 4.00) obtained from all sampled areas was partitioned into the following area damage classes: non-damaged (area damage index = 0.0), lightly damaged (0.00 < area damage index = 1.00), moderately damaged (1.00 < area damage index = 2.00), heavily damaged (2.00 < area damage index = 2.80), and very heavily damaged (2.80 < area damage index = 4.00).

Wickman (1978) reported that 25 to 95 percent of heavily defoliated (>90 percent defoliation) trees died from defoliation or bark beetle attack and that 90 percent of the mortality resulting from DFTM defoliation occurs in trees which have been heavily defoliated (>90 percent of total needle complement missing). Wickman's individual tree heavy defoliation class corresponds with our very heavy class. We used Wickman's correlations to predict the mortality which might result from the current outbreak in southern Idaho. We first determined the average number of precommercial- and commercial-sized trees within the very heavy individual tree defoliation class for all areas within each of the five area damage classes. We then multiplied the number of very heavily defoliated trees by 25 and 95 percent to obtain upper and lower mortality limits for an average area within each damage class. In addition, two intermediate mortality scenarios, a 40 and a 70 percent level were calculated.

A similar procedure was used to predict top-kill. Wickman (1978) reported that the rate of top-kill increased as the intensity of defoliation increased and developed the following coefficients or probability of top-kill for the various individual tree defoliation classes:

Individual Tree Defoliation Classes

Species	*Non*	*Light*	*Moderate*	*Heavy*	*Very Heavy*
DF	.00	.06	.18	.24	.13
TF	.00	.03	.13	.21	.27

We multiplied the number of trees per acre in each defoliation class within each stand by these values to estimate the number of trees that would be top-killed. These values were summed to estimate total top-kill within each area. These top-kill predictions were averaged for areas within like damage classes.

To evaluate population information in the lightly or non-defoliated areas, we first totaled the number of 1991 pupal cocoons found on the 60 branches inspected in each plot. This value was converted to the number of cocoons per 1,000 square inches of foliage by dividing the sum by 10,000. A three-branch sample contains approximately 500 square inches of foliage; therefore, a 60- branch sample contains approximately 10,000 square inches (Mason, per comm.[7]). The population estimates for all five plots were averaged to obtain the estimated number of cocoons per 1,000 square inches of foliage for the area. These area cocoon densities were substituted into a regression equation, $Y = 1.07 + 63.9 (X)$ where X = number of pupal cocoons per 1,000 square inches of foliage in year n and Y = number of early larvae per 1,000 square inches of foliage predicted in year n+1 (Mason, pers.

[7] Research Entomologist, Pacific Northwest Experiment Station, USDA Forest Service.

comm.[8]) to predict 1992 larval population densities. Predicted 1992 larval population densities were compared to larval densities associated with various levels of defoliation. Population densities of <20 larvae, 20 to 49 larvae, 50 to 99 and >99 larvae per 1,000 square inches are typically found in areas experiencing no defoliation, light to moderate defoliation, heavy defoliation, and total defoliation, respectively (Mason, pers. comm.[9]).

The number of eggs per mass is a good indicator of the vigor of the population (Mason et al. 1977). To estimate the number of eggs per mass we substituted egg mass weights into a regression equation $Y = 11.331 + 1.352(X)$ where X = the weight of an egg mass (mg) and Y = the predicted number of eggs in each mass (Beckwith et al. 1982). Predicted mean numbers of eggs per mass for each infestation were calculated and compared to each other and to means from the 1972-73 Blue Mountains outbreak.

Results: Ground data were collected and compiled for the Boise River infestation, the Sagehen/Squaw Creek infestation, and the Mann Creek/Brownlee Creek infestation. In addition, some areas displaying little or no defoliation but known to contain considerable susceptible host type were surveyed outside of the current infestation boundaries established from aerial surveys.

Boise River Infestation - Of the 27 areas sampled during the ground survey in the Boise River infestation, three areas were classified as non-damaged, six areas were lightly damaged, eight areas were moderately damaged, five areas were heavily damaged, and five areas were very heavily damaged. Douglas-fir is the predominant host species; however, subalpine fir is a suitable host at the higher elevations. The average stocking level for all 27 areas sampled is 132.4 (standard deviation (SD) = ±73.0) trees per acre. Stocking levels (basal area) for areas within the light, moderate, heavy, and very heavy damage classes were 151.5 (120.0), 147.6 (159.3), 145.7 (160.0), and 63.8 (102.4) trees per acre (square feet), respectively. Stocking levels were relatively consistant for all damage classes except for the very heavily damaged class, where fewer larger diameter trees were usually found. Table 6 lists the mean stocking levels for host and non-host trees greater than 5 inches d.b.h., stocking levels in various individual tree defoliation classes, area damage indices, and area damage classes for the Boise River infestation.

Only the moderate, heavy, and very heavy area damage classes contained very heavily defoliated trees (Table 6.). In very heavily damaged areas, an average of 4.9 precommercial- and 39.9 commercial-sized trees per acre were very heavily defoliated. Heavily damaged areas had a mean of 28.4 precommercial- and 35.9 commercial-sized trees which were very heavily defoliated; while moderately damaged areas had a mean of 10.2 commercial-sized trees which were very heavily defoliated. These averages are displayed in Table 7 along with the four mortality scenarios used to predict losses which might occur over the next four years. At the 25 percent mortality rate, 11.2, 16.1, and 2.5 trees per acre are predicted to die in very heavily, heavily, and moderately damaged areas, respectively. Under the 95 percent mortality scenario, approximately 42.6 trees per acre in the very heavily damaged areas may die. Eighty-nine percent of these trees (37.9 trees per acre) are of commercial size.

Top-kill is predicted to occur in all areas which have been defoliated (Table 8). Even the lightly defoliated areas are predicted to have some degree of top-kill on 7.0 trees per acre. Top-kill predictions for the Boise River infestation are summarized by area damage classes in Table 9.

---

[8] Research Entomologist, Pacific Northwest Experiment Station, USDA Forest Service.

[9] Research Entomologist, Pacific Northwest Experiment Station, USDA Forest Service.

Results of cocoon sampling in the non-defoliated and lightly defoliated areas indicate that the population has the potential to defoliate new area in 1992. Of the nine areas which were not defoliated or only lightly defoliated in 1991, five are predicted to reach population levels associated with very heavy defoliation in 1992. In these five areas, predicted early larval densities per 1,000 square inches of foliage for 1992 may average 221.91 (SD = ±67.33). Early larval population levels greater than 100 larvae per 1,000 square inches can cause total defoliation. In the remaining four areas, early larval densities may average 24.08 larvae (SD = ±18.31); levels associated with light defoliation. Table 10 summarizes the results of cocoon sampling and the early larval predictions. The realization of these population densities is dependent on the reproductive and survival rates of the population.

Reproductive rates can be estimated from egg mass sizes. Egg mass weights were measured and the mean number of eggs per mass were estimated for both defoliated and non-defoliated areas (Table 11). The mean number of eggs per mass is reported to be a good indicator of the vigor of the population. In defoliated areas, the predicted mean number of eggs per mass was 131 (SD = ±44). In non-defoliated or lightly defoliated areas, egg masses were predicted to contain 154 eggs in each mass. In heavily defoliated areas, egg masses are often smaller than in less heavily defoliated areas. One of the causes of this difference in egg mass size is probably the limited availability of food in the heavily defoliated areas. Egg mass sizes may also be indicative of the phase of the outbreak cycle (Mason et al. 1977). Larger egg masses have been reported during the building and peak phases of an outbreak. Number of eggs per mass declines as the vigor of the population declines and the outbreak subsides. Egg masses found in non-defoliated or lightly defoliated areas during 1992 are of a similar size to those found during the peak defoliation phase of the 1972-73 Blue Mountains outbreak. Those in the heavily defoliated areas are somewhat smaller and may indicate that the outbreak is entering the declining phases.

When this report was written, there was no way to determine survival rates. Laboratory survival rates from fall collected egg masses should be available in March, and these rates should be indicative of expected field survival rates.

Sagehen/Squaw Creek Infestation - Twelve areas were sampled in the Sagehen/Squaw Creek infestation. All of the areas were defoliated. Two of the 12 areas were classified during ground surveys as lightly damaged, three were moderately damaged, four were heavily damaged, and three were very heavily damaged. Grand fir composes 86 percent of the stocking while Douglas-fir makes up only 6 percent. The average stocking level for all 12 areas was 125.6 (SD = ±53.5) trees per acre. Stocking levels (basal area) for the light, moderate, heavy and very heavy area damage classes were 111.4 (112.0), 134.0 (114.7), 136.1 (118.0) and 112.6 (144.0) trees per acre (square feet), respectively. Stocking levels were relatively consistant across all area damage classes; however, the basal area occupied by these stocking levels differed slightly in the very heavy area damage class. On average, trees in the very heavy area damage class were larger diameter than trees in any of the other area damage classes. Table 12 lists the mean stocking levels for host and non-host trees greater than 5 inches d.b.h., stocking levels in various individual tree defoliation classes, area damage indices and area damage classes for the Sagehen/Squaw Creek infestation.

Only the heavy and very heavy area damage classes contained trees which have been very heavily defoliated. Very heavily damaged areas had a mean of 31.1 commercial- and 45.6 precommercial-sized trees per acre classified as very heavily defoliated; while heavily defoliated areas had a mean of 9.6 commercial- and 9.5 precommercial-sized trees per acre in the very heavy defoliation class. These averages are displayed on Table 13 along with the four mortality scenarios used to predict

losses which might occur over the next 4 years. At the 25 percent mortality rate, 19.2 and 4.8 trees per acre are predicted to die in very heavily and heavily defoliated areas, respectively. Under the 95 percent mortality scenario, approximately 73 trees per acre in the very heavily damaged areas may die. Forty-one percent of these trees (29.5 trees per acre) are of commercial size.

In addition to tree mortality, considerable top-kill may occur. Top-kill predictions range from 4.3 trees per acre in the light damage class to 16.6 in the very heavy damage class. Top-kill predictions for the Sagehen/Squaw Creek infestation are listed in Table 15.

Only two of the 12 sample areas qualified for cocoon population sampling. In these lightly defoliated areas, mean cocoon densities were 3.98 and 3.20 cocoons per 1,000 square inches of foliage. Based upon these samples, the 1992 early larval populations may exceed 200 larvae per 1,000 square inches in both areas and subsequent defoliation should be heavy (Table 16).

Egg masses in the Sagehen/Squaw Creek infestation averaged 161 and 145 eggs per mass in the non-defoliated and defoliated areas, respectively (Table 11). Egg mass sizes within this range are typical of populations capable of causing continued defoliation. Survival rates from fall-collected egg masses will be determined in March and this information should indicate if the predicted population levels are realistic.

Mann Creek/Brownlee Creek Infestation - Six areas were sampled in the Mann Creek/Brownlee Creek infestation. Two of the six areas were classified from ground survey data as heavily damaged, one as moderately damaged and three as lightly damaged. Grand fir is the most common tree species making up 67 percent of the stocking in the sampled areas. Douglas-fir is the next most common species comprising 23 percent of the stocking. The average stocking for trees greater than 5 inches d.b.h. is 85.2 (SD = ±24.7) trees per acre, and the average basal area is 113.3 (SD = ±33.1) square feet. Table 17 lists the mean stocking levels for host and non-host trees greater than 5 inches d.b.h., stocking levels in various individual tree defoliation classes, area damage indices, and area damage classes for the Mann Creek/Brownlee Creek infestation.

Only the heavy area damage class had trees which were very heavily defoliated. The average number of trees per acre with a high probability of dying in areas classified as heavily damaged is 8.7. Table 17 lists the mean number of trees per acre and the mean basal area for precommercial- and commercial-sized trees which fall into the very heavy defoliation class.

Four mortality scenarios have been calculated for this infestation. Table 18 displays the number of trees predicted to die within areas classified as damaged under the four mortality scenarios. Based upon these predictions, mortality ranging from 2.2 to 8.3 trees per acre can be expected in the heavily damaged areas. In addition, top-kill should be expected on 2.5, 7.2, and 16.0 trees per acre in the lightly, moderately, and heavily damaged areas, respectively (Table 20).

Three of the six areas were lightly defoliated and cocoon sampling was performed in order to predict expected DFTM populations trends in 1992. In two of the areas, 1992 early larval populations are predicted to exceed 100 larvae per 1,000 square inches of foliage, the population level associated with very heavy defoliation. In the other area, the population is expected to reach levels associated with light to moderate defoliation. These data and predictions are summarized in Table 21. Egg mass sizes averaged 183 eggs per mass in the lightly or non-damaged areas and 144 eggs per mass in the defoliated areas (Table 11). These egg mass sizes are typical of the defoliation phases of an outbreak cycle.

Other Survey Areas - Several additional areas were surveyed which were composed predominantly of host type and were of high resource value. Bald Mountain, the ski area for Sun Valley, displayed no aerially visible defoliation in 1991. Twelve transects were installed in order to compile site and green tree information and DFTM population estimates. Four of the 12 areas showed evidence of some tussock moth feeding. This minor defoliation was only evident when viewed close-up and only found on a few branches per tree. Stocking levels and basal area in the areas sampled averaged 205.6 trees per acre and 170 square feet. This information is listed in Table 22.

In eight of the 12 areas, DFTM cocoons were found; however, only three of these areas are predicted to have 1992 populations capable of causing visible defoliation. In 1992, one sample area on the Warm Springs side could be very heavily defoliated and two areas on the Cold Springs side could be defoliated, one heavily and one moderately. Table 23 summarizes this information. Egg masses collected from Bald Mountain were smaller on average than egg masses collected from other non-defoliated or lightly defoliated areas. Egg mass sizes averaged 133.2 eggs per mass. These egg masses are still larger than egg masses found during the decline phase of the Blue Mountains outbreak.

Two areas outside of the infestation boundaries were sampled on the Boise National Forest; Bogus Basin and Sunset Mountain. Very little evidence of tussock moth was found at Bogus Basin. Populations are predicted to be low in 1992. No defoliation should be anticipated.

Sunset Mountain, however, is an area of concern. Four of the eight areas sampled displayed some limited defoliation. All of the currently infested areas are southeast of Idaho Highway 21. Stocking in the defoliated and non-defoliated areas averaged 61.2 and 91.4 trees per acre, respectively; while basal areas averaged 120 and 100 square feet, respectively. This indicates that the defoliated areas have slightly fewer trees but the trees are larger. This information is summarized in Table 24. At the current level of defoliation, no tree mortality caused by DFTM is expected to occur. Some top-kill could occur, and the top-kill predictions range from 1.0 to 6.4 trees per acre. Table 25 lists these top-kill predictions.

Cocoons were easily found in all but one area. Early larval densities in 1992 are predicted to average 76.22 larvae per 1,000 square inches of foliage in areas on the southeast side of Idaho Highway 21. Expected defoliation in 1992 should be heavy if natural controls do not prevail. At least one area is predicted to have larval populations associated with very heavy defoliation. This information is summarized in Table 26. Egg masses collected from Sunset Mountain were similar in size to those found on Bald Mountain but they are smaller than those found in other outbreak areas. The average egg mass contained approximately 134 eggs per mass (Table 11).

Eight, non-defoliated areas were sampled on the Payette National Forest. Only one area (Paddy Flat) displayed any defoliation. Populations are expected to be very low in 1992; therefore, no defoliation is anticipated. Green tree information for these areas is summarized in Table 27, and DFTM population data are summarized in Table 28.

DISCUSSION & SUMMARY

Considerable information has been gathered during the 1990-91 DFTM outbreak in order to document the current situation and to predict the population trend and impacts. This report summarizes that information.

This is the largest DFTM outbreak ever recorded in southern Idaho. There are several areas of defoliation which are isolated from one another. In this report we have classified these areas into five separate infestations; the Boise River infestation, the Sagehen/Squaw Creek infestation, the Mann Creek/Brownlee Creek infestation, the Owyhee Mountains infestation, and the Hailey/Bellevue infestation. Most of these outbreak areas differ in stand composition, stocking, and other site related factors. Likewise DFTM populations also differ.

Boise River Infestation - Empirical and subjective evidence indicates that the very heavily defoliated areas in the Middle and the South Fork drainages of the Boise River will probably not support outbreak DFTM population levels for another year. Fringe areas which were non-defoliated or only lightly defoliated in 1991 may support populations with increasing defoliation intensities in 1992. Impacts in the very heavily damaged areas could average as high as 42.6 trees killed per acre; but, previous history in the area suggest that impacts will be considerably less, perhaps more in the range of 11.2 to 18.0 trees per acre. Larval mortality caused by virus was observed in 1991 in several areas within the outbreak boundary. We suspect that parasitism, starvation, and increased viral mortality rates in the defoliated areas will cause the population to collapse by mid summer.

Sagehen/Squaw Creek Infestation - The Sagehen/Squaw Creek infestation has many heavily defoliated areas but there appears to be more lightly and moderately defoliated areas which could support outbreak population levels of DFTM. Therefore, we suspect that this infestation will continue particularly in areas around Sagehen Reservoir. Impacts could be as high as 72.8 trees killed per acre in the very heavily damaged areas. Unfortunately, we have very little historical impact information from this area so we are uncertain as to the impacts we should anticipate. We suspect that the impacts will probably be considerably less. Mortality rates of 7.8 to 12.4 commercial-sized trees per acre are probably more realistic for the very heavily damaged areas. Egg mass densities and sizes in lightly defoliated areas suggest that the outbreak will continue. Larval mortality caused by virus was observed but the role virus will play in population control is unknown.

Mann Creek/Brownlee Creek Infestation - This infestation is rather unique because of the mixed DFTM and WSBW populations. DFTM populations and visible defoliation have been present for 2 years but the DFTM population has not reached densities found in the Boise River or Sagehen/Squaw Creek infestations. Budworm may out-compete DFTM by depleting some of the early food supply prior to the emergence of DFTM. Larval mortality caused by virus has been observed scattered throughout the infestation. Of all the areas surveyed, egg masses from the Mann Creek/Brownlee Creek infestation contain, on average, more eggs. Larger egg masses are indicative of more vigorous populations. Based upon the information compiled in this survey, we suspect that the DFTM outbreak will continue in this area. Intensity of defoliation and subsequent impacts are less than that observed in other outbreak areas. Impacts associated with the 1991 levels of defoliation should be minimal in the Mann Creek/Brownlee Creek infestation.

Two lightly or non-defoliated areas of concern include Bald Mountain on the Sawtooth National Forest and BLM, and Sunset Mountain on the Boise National Forest. Current population samples in both areas indicate that the 1992 populations could reach levels capable of causing visible

defoliation. Presently, the Sunset Mountain area which displays some light defoliation has the greater potential to experience heavier levels of defoliation. Egg mass sizes are smaller in these areas which may indicate that the current DFTM populations are not as vigorous as they have been in other areas across southern Idaho.

The remaining areas which were surveyed in 1991 are of little concern.

Ground surveys completed in 1991 surveyed only a small proportion of the infested areas. Other isolated areas of defoliation exist which were not surveyed. The outbreak is widespread and additional areas of defoliation may become apparent in 1992.

In summary, we suspect that the regional outbreak has peaked across southern Idaho. Additional defoliation may be detected in 1992 as the populations begin to decline. It may take more than one year for populations to subside in fringe areas.

MANAGEMENT ALTERNATIVES

Management alternatives for dealing with DFTM outbreaks follow:

No action alternative - Under the no action alternative, the outbreak would be allowed to run its course. Usually this would be a 3- to 4-year period. Because nothing has been done to disturb the complex of natural controlling agents, the population would collapse when the controlling agents are able to reduce the population to endemic levels.

Trees which are defoliated repetitively and retain less than 10 percent of their foliage have a high probability of dying. Top-kill of Douglas-fir, subalpine fir, and grand fir will be evident particularly in the more heavily defoliated stands. As the rate of top-kill increases, the incidence and severity of stem decay and root decay may also increase.

Growth rates will be slowed in host trees as a result of defoliation but recovery should occur shortly after defoliation subsides.

Douglas-fir beetle and western balsam bark beetle will continue to cause mortality in the area. Defoliation is likely to increase the susceptibility of trees to bark beetle attack.

The advantages of this alternative are that no insecticides are introduced into the ecosystem, and the populations remain under natural control. In addition, reductions in forest cover may increase the regeneration potentials of seral, shade intolerant species and increase water yield and game forage.

Disadvantages of this alternative include increases in tree mortality which may result in reduced timber values, recreational usage, and visual quality.

Salvage Alternative - Under this alternative, trees that are expected to die would be removed with the overall objectives of improving the vigor of the leave trees and recovering some value from the salvaged trees. These activities will have little or no effect on the DFTM populations. They may help to reduce additional mortality associated with subsequent bark beetle outbreaks and other pest activity. Refer to the discussion section of this report to assist in determining which

trees should be removed. When possible, the salvage alternative should address other pests and improvements in stand conditions which will result in improvements in stands health.

The advantages of this alternative include recovery of some monetary value from dead and dying trees, improvement of stand health, and elimination of hazards associated with dead trees.

Disadvantages include the added cost of planning and implementing a salvage sale.

Direct Suppression Alternative - Direct suppression of DFTM populations on large blocks of forest lands is best accomplished through aerial applications of either chemical or biological insecticides. The direct suppression alternative is usually considered when DFTM populations are in the building phase of an outbreak. The direct suppression alternative is seldom considered after heavy defoliation has occurred.

Aerial application of chemical insecticides - Aerial application of chemical insecticides are effective in reducing DFTM population to suboutbreak levels. Applications are most effective if large contiguous blocks can be treated. Applications are usually made in June after larval dispersal. Registered insecticides include acephate, carbaryl, and dimilin. Chemical insecticides are usually less selective than the registered biological insecticides; therefore, their use must be carefully evaluated in terms of other environmental constraints.

Advantages of chemical applications include rapid knock down of DFTM populations and protection of current foliage, thereby reducing subsequent tree mortality.

Disadvantages associated with this alternative include the introduction of a chemical insecticide into the ecosystem with some disruption to the natural balance and the costs incurred in planning and implementing a chemical insecticide project.

Aerial application of biological insecticides - Biological insecticides which are registered for suppression of DFTM include *Bacillus thuringiensis*, *B.t.*, and a nuclear polyhedrosis virus, TM Biocontrol-1™. The virus is specific to tussock moths while *B.t.* is toxic to most lepidopterous insects. Biological insecticides require careful timing in order to effectively reduce populations.

Advantages of biological applications include suppression of DFTM populations with minor environmental consequences.

A disadvantage of this alternative over the chemical alternative is that foliage protection during the year of the application is usually less effective.

LITERATURE CITED

Beckwith, R.C.; Mason, R.R.; Paul, H.G. 1982. How to determine the number of Douglas-fir tussock moth eggs from egg mass weight. USDA Agriculture Handbook 599. 7p.

Bousfield, W.; Eder, R.; Bennett, D. 1985. Users guide and documentation for insect and disease damage survey (INDIDS). R-1 85-19. USDA Forest Service, Northern Region, Missoula, Montana. 19p.

Daterman, G.E.; Livingston, R.L.; Wenz, J.M.; Sower, L.L. 1979. How to use pheromone traps to determine outbreak potential. USDA Agricultural Handbook 546. 11p.

Mason, R.R.; Beckwith, R.C.; Paul, H.G. 1977. Fecundity reduction during collapse of a Douglas-fir tussock moth outbreak in Northeast Oregon. Environ. Entomol. 6(5): 623-626.

Tunnock, S.; Ollieu, M.; Thier, R.W. 1985. History of Douglas-fir tussock moth and related suppression efforts in the Intermountain and Northern Rocky Mountain Regions – 1927 through 1984. USDA Forest Service, Report No. 85-13. Intermountain and Northern Regions, Missoula, Montana. 51p.

Wickman, B.E. 1978. Tree mortality and top-kill related to defoliation by the Douglas-fir tussock moth in the Blue Mountains outbreak. USDA Forest Service, Research Paper PNW-233. Pacific Northwest Forest and Range Experiment Station, Portland, Oregon. 47p.

Wickman, B.E.; Mason, R.R.; Trostle, G.C. 1981. Douglas-fir tussock moth. USDA Forest Service, Forest Insect & Disease Leaflet 86. 10p.

Weatherby, J.C.; K.A. Knapp; Gardner, B.R. 1991. A biological evaluation of the Douglas-fir tussock moth outbreak in southern Idaho, 1990. USDA Forest Service, Report No. R4-91-04. Intermountain Region, Ogden, Utah. 18p.

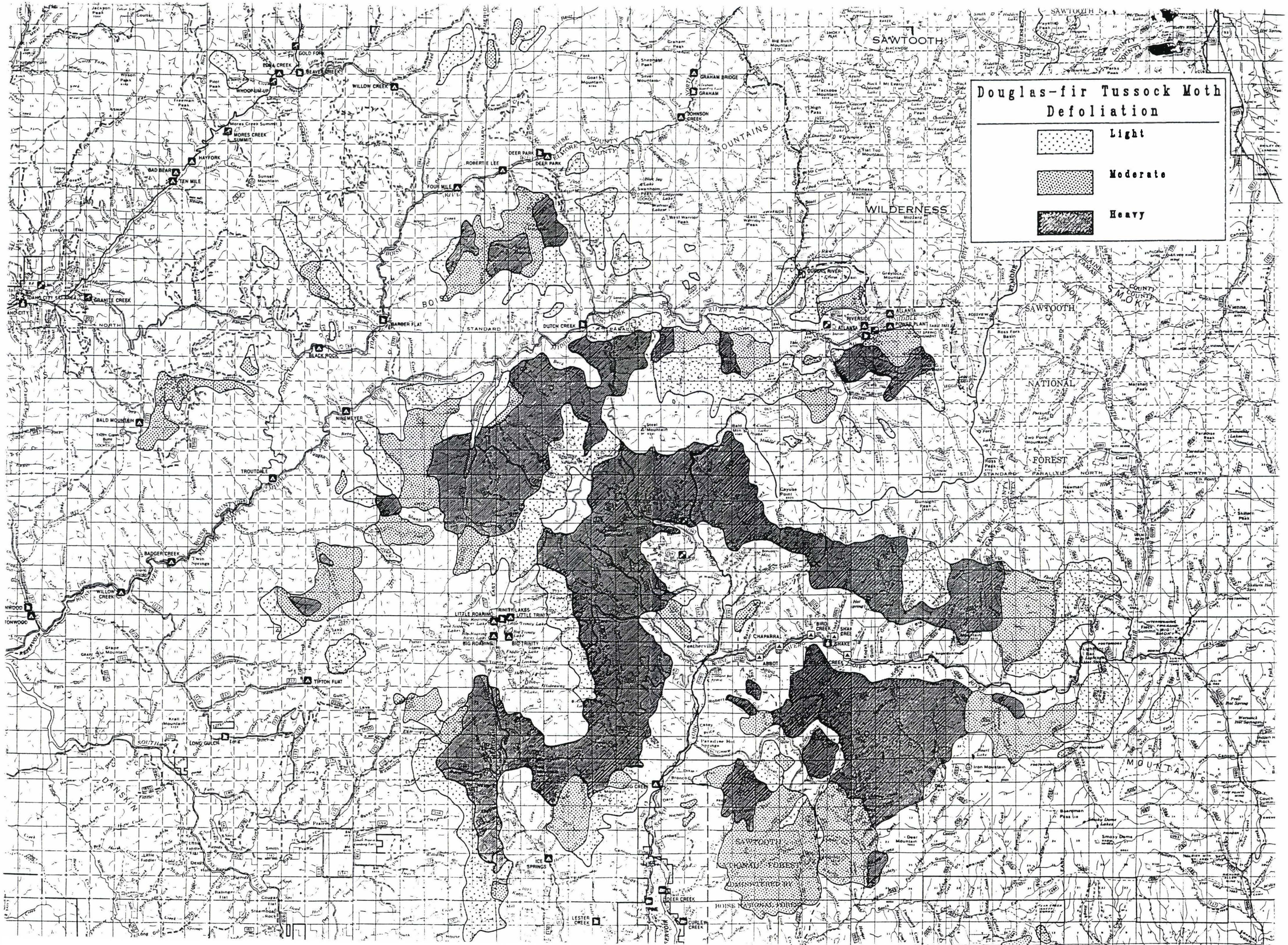

Figure 1.–Areas and intensity of visible defoliation detected during the aerial detection survey of the Boise River infestation of the Douglas-fir tussock moth, 1991.

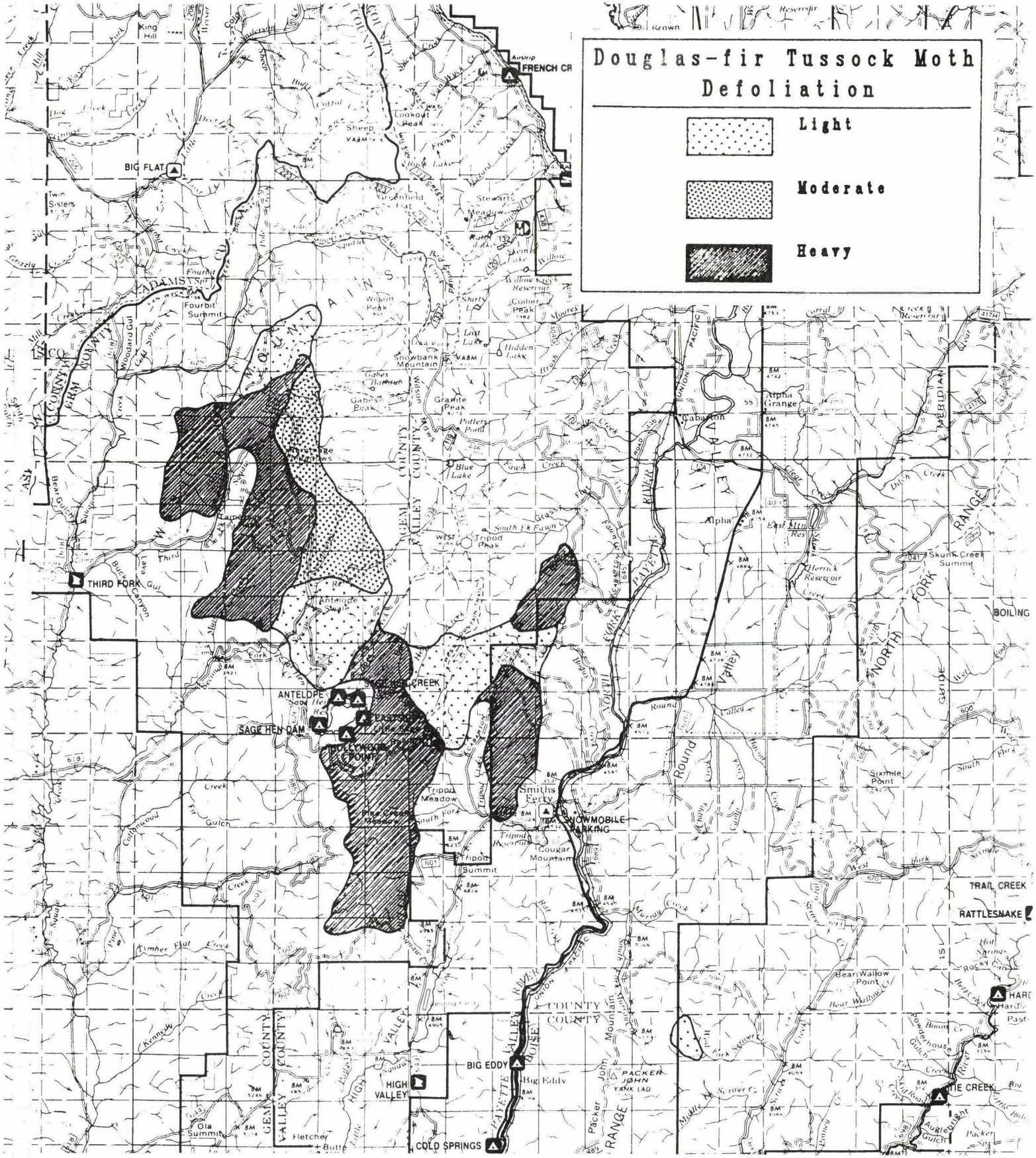

Figure 2.–Areas and intensity of visible defoliation detected during the aerial detection survey of the Sagehen/Squaw Creek infestation of the Douglas-fir tussock moth, 1991.

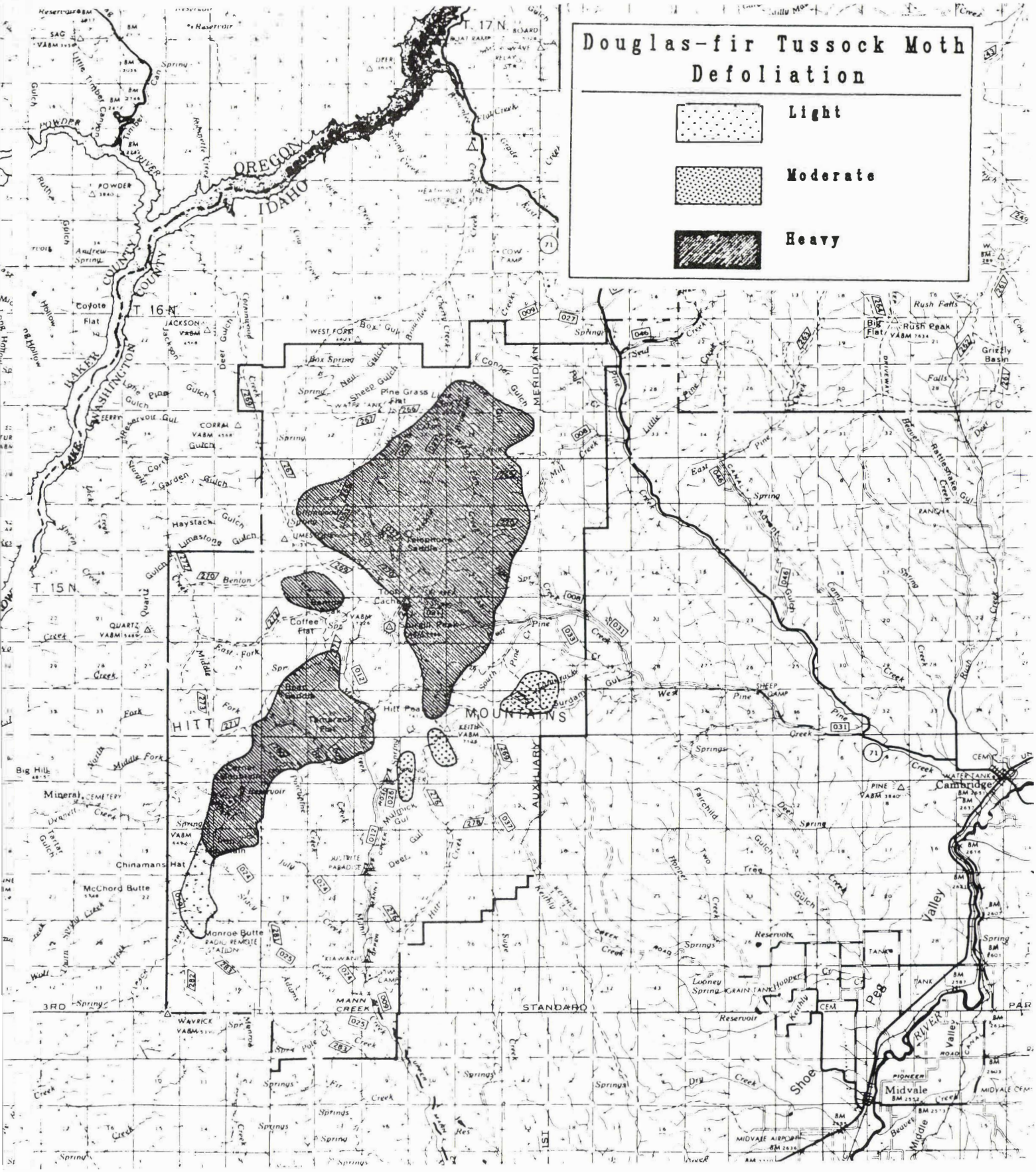

Figure 3.–Areas and intensity of visible defoliation detected during the aerial detection survey of the Mann Creek/Brownlee Creek infestation of the Douglas-fir tussock moth, 1991.

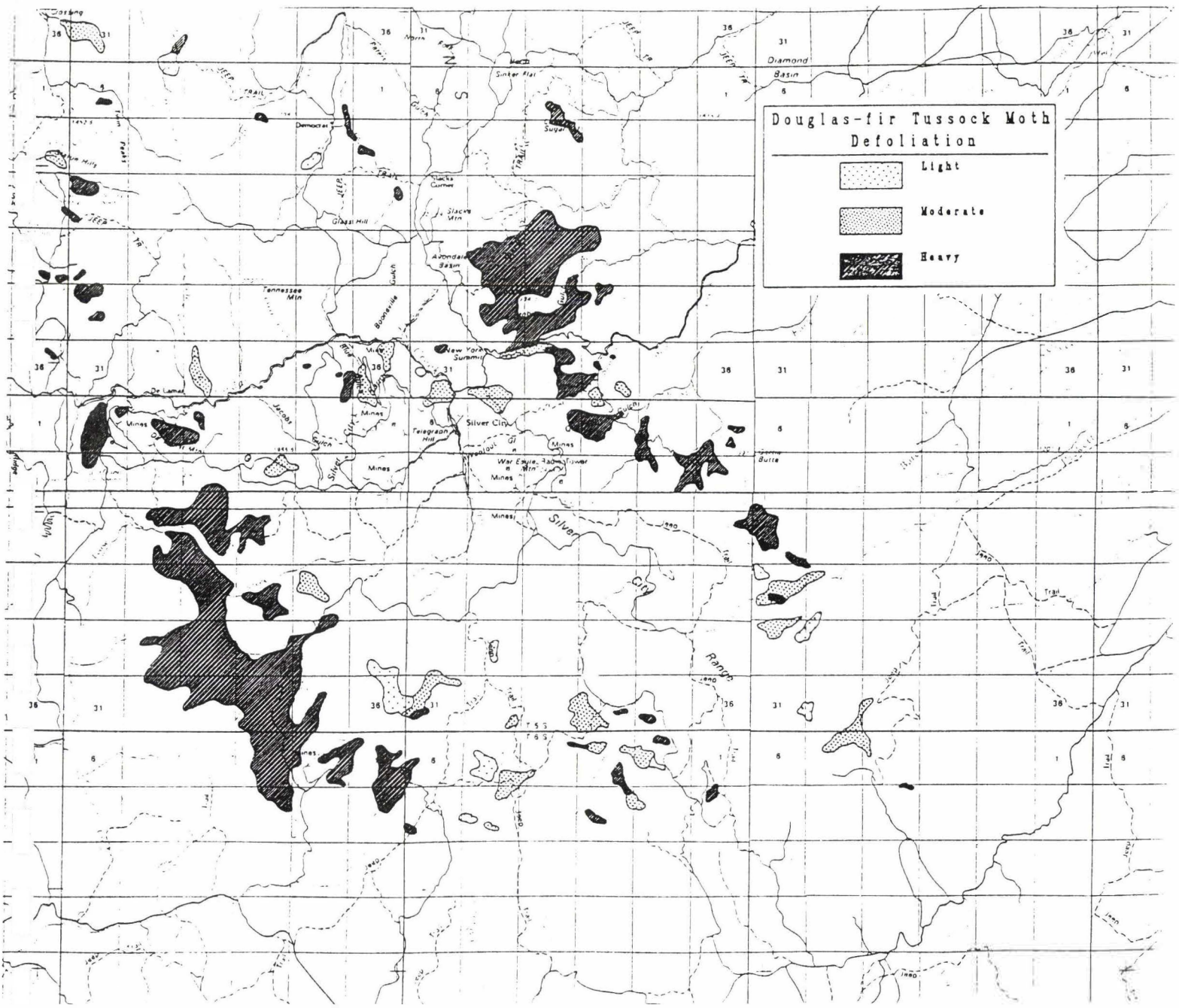

Figure 4.–Areas and intensity of visible defoliation detected during the aerial detection survey of the Owyhee Mountains infestation of the Douglas-fir tussock moth, 1991.

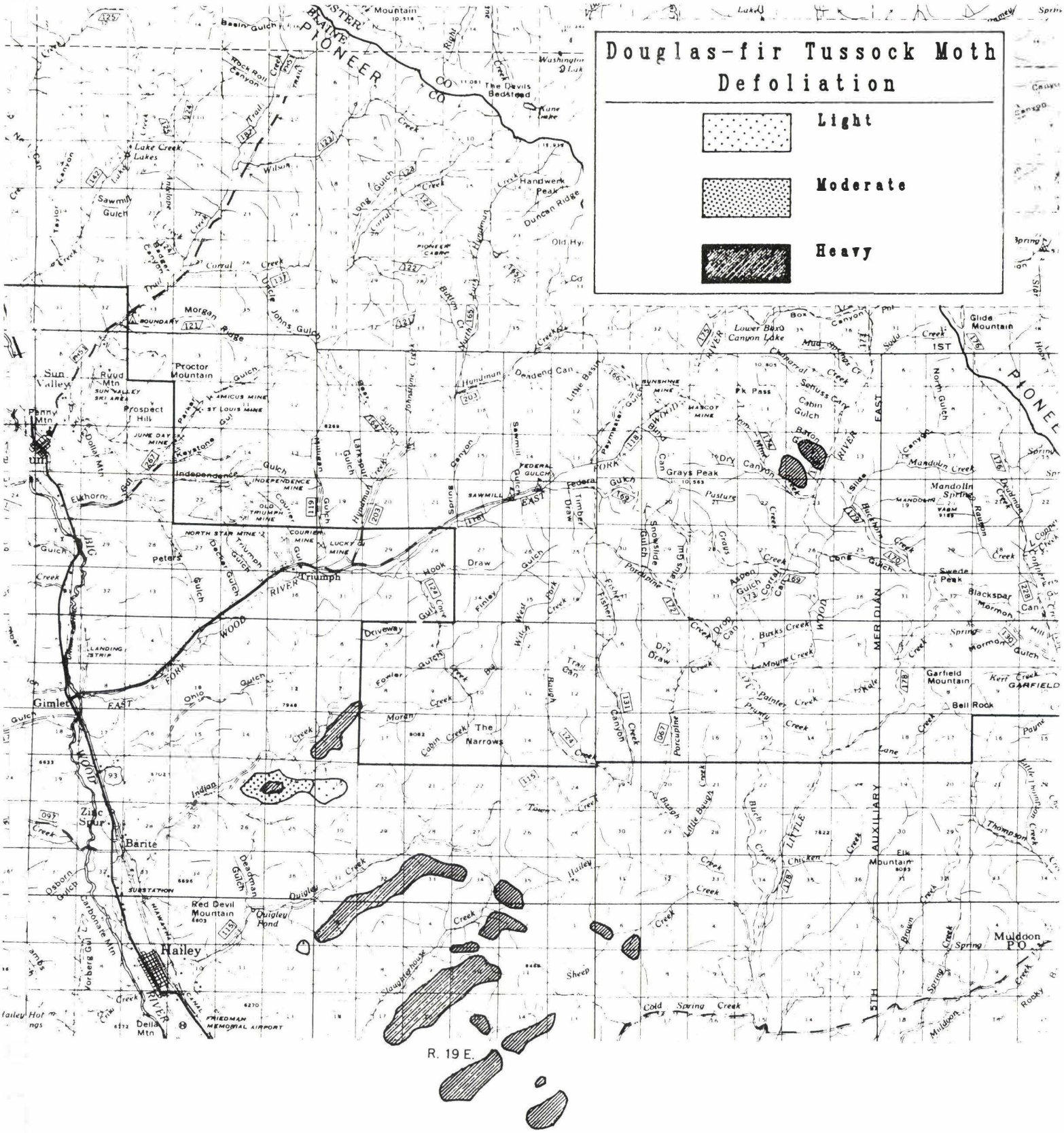

Figure 5.–Areas and intensity of visible defoliation detected during the aerial detection survey of the Hailey/Bellevue infestation of the Douglas-fir tussock moth, 1991.

Table 1.--Average number of male Douglas-fir tussock moths caught in pheromone-baited sticky traps distributed in southern Idaho, 1981 to 1991.

Site	Mean Number of Male Douglas-fir Tussock Moths/Trap by Year										
	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Boise NF											
Bear Creek	*	0.0	32.8	0.4	0.0	1.2	1.4	0.6	0.2	31.6	25.6
Skunk Creek	0.2	0.6	29.0	0.0	1.0	1.2	0.2	0.2	0.0	5.3	*
Deer Point	*	*	*	*	*	*	*	*	*	65.6	35.6
Payette NF											
Adams Creek	*	53.6	39.6	7.8	4.0	17.6	8.8	1.8	2.6	78.6	40.4
Barinaga Corral	*	*	44.2	0.4	2.8	4.0	2.0	0.0	1.0	9.6	8.0
Bear Saddle	*	15.2	44.0	1.0	0.2	0.2	0.4	0.0	0.0	84.8	8.4
E. Fk. Brownlee	*	61.2	50.6	2.6	3.4	27.0	6.0	0.2	0.4	56.8	6.0
Fourbit Creek	*	49.8	42.8	*	4.8	30.4	2.0	2.2	1.2	37.0	*
McDowell Trail	*	*	35.8	5.0	6.8	24.6	1.2	0.0	0.0	26.8	3.4
Olive Creek	*	36.8	51.2	14.6	10.5	46.8	9.8	3.2	0.5	19.4	7.0
Seid Creek	*	*	17.4	11.2	*	27.2	4.8	1.6	0.4	51.6	18.4
Stacy Creek	*	*	42.8	18.0	8.8	3.8	5.0	0.0	0.4	63.2	43.2
Salmon NF											
Colson Creek	*	15.2	39.0	3.2	*	7.2	5.2	14.0	0.6	0.4	*
Lick Creek	*	7.6	38.4	0.6	*	6.0	0.6	28.5	0.6	0.4	*
Sawtooth NF											
Little Water Gulch	3.8	13.6	27.0	17.2	0.0	34.6	26.6	4.0	32.5	102.0	76.0
Virginia Gulch	0.6	2.0	26.8	1.8	0.0	4.8	6.8	2.6	0.4	58.6	62.0
Idaho State Lands											
Sharps Canyon	19.4	16.2	41.2	1.3	5.2	22.6	8.4	36.4	9.2	53.2	*
BLM Lands											
Dewey Peak	64.0	*	*	15.0	1.6	33.7	38.6	47.0	36.3	80.4	73.0
Mill Creek	47.6	*	*	6.6	0.0	0.4	0.0	0.2	0.2	53.0	87.6
New York Summit	*	*	*	0.0	*	1.8	3.8	15.0	12.6	71.8	82.8
So. Fk. Boulder Ck.	*	*	*	0.7	0.2	1.8	0.2	0.8	2.2	96.8	61.0
Mean	22.6	22.7	37.7	5.7	3.1	14.9	6.6	7.8	5.1	50.1	39.9

* Not sampled.

Table 2.--Locations of pheromone-baited trapping sites and average male moths captured per traps in southern Idaho, 1991.

Site	Location T.	R.	Sec.	Date Instl.	Date Retrv.	Mean male (moths/trap)
Boise NF						
Bogus X-Ski	5N	3E	16	7/31	10/28	24.0
Shafer Butte	5N	3E	10	7/31	10/28	14.6
Squaw Ck.	13N	2E	9	7/30	10/24	18.2
Tamarack Flat	12N	2E	8	7/30	10/24	45.0
Antelope Trail	12N	2E	10	7/30	10/24	30.6
Little Sagehen	11N	2E	1	7/31	10/23	31.0
Cottonwood Ck.	12N	2E	32	7/31	11/15	47.3
Bridge Ck.	11N	5E	4	7/31	11/13	4.8
Silver Ck. CG	12N	6E	19	7/31	11/13	3.2
Hardscrabble	11N	5E	32	7/31	11/13	1.8
Upper Scriver Ck	11N	4E	22	8/1	11/14	3.2
Lower Scriver CK	10N	4E	20	8/1	11/13	11.8
Lost Man Ck.	5N	9E	31	8/8	11/13	117.4
Roaring River	5N	8E	26	8/8	11/13	95.2
Trinity Lk Rd	4N	9E	29	8/8	*	*
Cow Ck.	3N	10E	4	8/2	11/12	53.6
Wide West Gulch	4N	10E	20	8/2	11/12	92.0
W. Parkes Ck.	3N	9E	2	8/2	11/12	80.6
Wagontown Ck.	3N	10E	18	8/2	11/12	49.4
Upper Rock Ck.	7N	6E	12	7/31	11/12	6.6
Lower Rock Ck.	8N	7E	15	7/31	11/12	23.4
Banner Ridge	8N	7E	23	7/31	11/12	39.2
Banner Ck.	8N	8E	29	7/31	11/12	8.0
Crooked River	8N	8E	34	7/31	11/12	25.8
Willow Ck.	7N	8E	14	7/31	11/12	52.4
Rough Ck.	11N	9E	30	8/20	*	*
Horse Ck.	10N	8E	16	8/20	11/7	12.2
O'Keefe Ck.	10N	7E	25	8/20	11/7	18.0
Park Ck. CG	9N	7E	13	8/20	11/7	1.4
Whitehawk	11N	8E	20	8/19	*	*
Wilson Ck.	12N	7E	34	8/19	*	*
Threemile	11N	7E	19	8/19	*	*
Scott Ck.	10N	6E	15	8/19	*	*
Slaughterhouse	9N	7E	20	8/19	11/7	61.6
Warm Lake Ck.	15N	7E	16	7/29	11/8	0.0
Tule Lake	15N	6E	14	7/29	*	*
Rice Ck.	14N	7E	18	7/30	11/8	0.6
Lodgepole Ck.	15N	7E	31	7/30	11/8	1.4
Bear Ck.	4N	10E	7	8/2	11/12	25.6
Skunk Ck.	12N	4E	14	*	*	*
Deer Point	5N	3E	29	7/31	10/28	35.6
Payette NF						
Hitt Ck	14N	5W	4	7/29	10/29	8.4
Mann Ck.	14N	5W	4	7/29	10/29	16.6
South Pine	15N	5W	25	7/30	10/30	25.2
Mill Ck. Rd.	15N	4W	6	7/30	10/31	51.8
Tool Cache	15N	5W	15	7/30	10/30	17.6
Middle Brownlee	15N	5W	3	7/30	10/30	7.8
Cottonwood	15N	5W	8	7/30	10/30	12.8
Kennally Ck.	17N	4E	26	8/6	10/29	10.8
Powelson Ck.	17N	5E	19	8/6	*	*
Sloan Point	16N	4E	1	8/6	10/29	20.0
Brown Ck.	20N	2E	18	8/5	10/30	9.6
Sixmile Ck.	20N	2E	28	8/5	10/30	16.6
Last Chance	19N	2E	15	8/5	10/30	3.6
Brundage Ski	19N	2E	12	8/6	10/29	3.4
Bear Basin	19N	3E	30	8/6	10/29	0.3
Yantis Ditch	5S	1W	10	8/14	11/5	9.2
Chokecherry	4S	1W	12	8/14	*	*

* Traps not collected.

Table 2.--Locations of pheromone-baited trapping sites and average male moths captured per trap in southern Idaho, 1991.--Continued.

Site	Location T.	R.	Sec.	Date Instl.	Date Retrv.	Mean male (moths/trap)
Payette NF						
Ant Basin Ck.	5S	1W	34	8/14	11/5	1.8
Mud Ck.	5S	1W	13	8/14	11/5	4.0
Brush Ck.	21N	1E	28	8/15	*	*
E. Fk Lost Ck.	6S	1W	21	8/8	11/5	6.0
Sheep Ck.	7S	1W	17	8/8	11/5	25.0
Lost Ck.	8S	1W	14	8/8	11/5	5.4
4th of July Ck.	7S	2W	1	8/14	11/5	7.2
Bluebunch	17N	1E	1	8/1	11/4	5.2
Squaw Flat	17N	2E	32	8/1	11/5	3.4
E. Fk Weiser Rv	17N	1E	21	8/7	11/4	17.0
Dry Beaver Ck.	17N	1E	10	8/7	11/4	18.6
Joker/Dewey	17N	2E	13	8/7	11/4	0.4
Cabin Ck. CG	15N	1E	12	7/31	11/6	4.2
Johnson Park	9S	2W	32	7/31	11/5	3.4
Goodrich Ck.	9S	2W	7	7/31	11/5	0.6
Orchid Canyon	9S	2W	4	7/31	11/5	7.4
Adams Ck.	14N	6W	23	7/29	1031	40.4
Barinaga Corral	5S	2W	14	8/8	11/6	8.0
Bear Saddle	15N	5W	31	7/29	10/29	8.4
E.Fk. Brownlee	16N	4W	3	7/30	11/4	6.0
Fourbit Ck.	13N	2E	7	*	*	*
McDowell Trail	8S	2W	17	7/31	11/5	3.4
Olive Ck.	8S	2W	6	7/31	11/5	7.0
Seid Ck.	16N	4W	21	7/30	11/4	18.4
Stacey Ck.	14N	6W	14	7/29	10/31	43.2
Salmon NF						
Colson Ck.	23N	16E	12	*	*	*
Lick Ck.	26N	22E	32	*	*	*
Sawtooth NF						
Paradise Springs	3N	10E	33	7/27	10/17	71.0
Grouse Ck.	3N	10E	36	7/27	10/17	67.6
Mid Fk Grouse Ck	2N	11E	6	7/27	10/16	75.8
Little Water	3N	12E	7	8/2	10/18	76.0
Virginia Gulch	3N	11E	9	8/2	10/18	62.0
Idaho State Lands						
Pine Ridge Rd.	7S	1W	35	8/8	11/5	25.0
Sharps Canyon	2N	19E	36	*	*	*
BLM Lands						
Dewey Peak	6S	4W	3	7/30	11/15	73.0
Mill Ck.	8S	5W	12	7/31	11/1	87.6
NY Summit	4S	3W	32	7/30	11/15	82.8
S Fk. Boulder Ck	8S	5W	24	7/30	11/15	61.0

* Traps not collected.

Table 3.--Average mean male moth catch in designated infestations in southern Idaho, 1991.

Infested Area	Average mean male (moths/trap)
Sagehen/Squaw Ck.	36.2
Boise River	72.2
Owyhee Mountains	76.1
Mann Ck./Brownlee Ck.	23.2
Hailey/Bellevue	*
All other areas with light or no defoliation	12.3

* Area not sampled.

Table 4.--Mean number of cocoons recovered per cryptic shelter at sites scattered across southern Idaho, 1987 to 1991.

Site	Mean Number Pupal Cocoons/Shelter				
	1987	1988	1989	1990	1991
Boise NF					
Bear Ck.	0.00	0.00	0.10	0.05	11.25
Skunk Ck.	0.00	0.00	0.00	0.00	*
Deer Point	*	*	*	*	*
Payette NF					
Adams Ck.	0.00	0.10	0.17	1.50	5.80
Barinaga Corral	0.00	0.00	0.05	*	*
Bear Saddle	0.00	0.00	0.25	*	*
E Fk Brownlee	0.05	0.00	0.10	0.20	1.00
Fourbit Ck.	0.05	0.00	0.00	0.00	*
McDowell Trail	0.00	0.00	0.00	0.00	0.20
Olive Ck.	0.00	0.00	0.00	*	*
Seid Ck.	0.00	0.00	0.00	0.00	0.00
Stacey Ck.	0.00	0.10	0.15	0.90	7.50
Salmon NF					
Colson Ck.	0.05	0.05	0.18	0.00	*
Lick Ck.	0.00	0.00	0.00	0.00	*
Sawtooth NF					
Little Water Gulch	0.20	0.20	0.20	0.90	4.65
Virginia Gulch	0.10	0.00	0.00	0.00	3.35
Idaho State Lands					
Sharps Canyon	0.05	0.00	0.20	0.85	*
BLM Lands					
Dewey Peak	0.25	0.30	1.20	11.35	2.65
Mill Ck.	0.00	0.00	0.05	0.15	1.70
New York Summit	0.00	0.00	0.20	0.60	1.60
S Fk Boulder Ck.	0.00	0.00	0.00	0.15	0.00
Mean	0.04	0.04	0.14	0.98	3.30
SD	0.07	0.08	0.26	2.71	3.30

* Not sampled.

Table 5.--Mean number of healthy female and male cocoons and the mean number of failed cocoons recovered per cryptic shelter at sites scattered across southern Idaho, 1991.

Site	No. Shelters	Mean No. Pupal Cocoons/Shelter		
		Females	Males	Failed
Boise NF				
Bear Ck.	20	0.65	8.05	2.55
Skunk Ck.	20	*	*	*
Deer Point	0	*	*	*
Payette NF				
Adams Ck.	15	0.20	5.47	0.13
Barinaga Corral	0	*	*	*
Bear Saddle	0	*	*	*
E Fk Brownlee	20	0.00	1.00	0.00
Fourbit Ck.	20	*	*	*
McDowell Trail	20	0.00	0.20	0.00
Olive Ck.	0	*	*	*
Seid Ck.	20	0.00	0.00	0.00
Stacey Ck.	20	1.10	6.10	0.30
Salmon NF				
Colson Ck.	20	*	*	*
Lick Ck.	20	*	*	*
Sawtooth NF				
Little Water Gulch	20	1.25	3.10	0.30
Virginia Gulch	20	0.40	2.55	0.40
Idaho State Lands				
Sharps Canyon	20	*	*	*
BLM Lands				
Dewey Peak	20	0.15	1.50	1.00
Mill Ck.	20	0.40	0.40	0.90
New York Summit	20	0.15	1.05	0.45
S Fk Boulder Ck.	20	0.00	0.00	0.00
Mean		0.36	2.50	0.50
SD		0.41	2.59	0.70

* Not sampled.

Table 6.--Mean stocking levels for host and non-host tree species greater than 5 inches d.b.h., stocking levels by defoliation class, stocking levels of precommercial- and commercial-sized trees in the very heavy defoliation class, area damage indices, and area damage classes for sampled areas in the Boise River infestation, Sawtooth and Boise National Forests, 1991.

						Individual Tree Defoliation Classes					V. Heavy Class		Area Damage	
Area	Line		Total	DF	SAF	Non-Host	No[a]	Light[b]	Mod.[c]	Heavy[d]	V. Heavy[e]	Pre.[f]	Comm.[g]	Index[h]	Class[i]
Marsh Creek															
	1	TA	273.4	273.4			0.0	76.6	148.3	48.4	0.0	0.0	0.0	1.90	M
		BA	200.0	200.0			0.0	80.0	100.0	20.0	0.0	0.0	0.0		
	13	TA	120.7	115.6		5.1	5.1	82.4	33.3	0.0	0.0	0.0	0.0	1.23	M
		BA	200.0	180.0		20.0	20.0	160.0	20.0	0.0	0.0	0.0	0.0		
	14	TA	107.0	107.0			3.2	14.1	2.9	40.7	0.0	0.0	0.0	1.33	M
		BA	96.0	96.0			8.0	24.0	8.0	8.0	0.0	0.0	0.0		
	15	TA	26.9	26.9			0.0	8.5	5.3	11.5	1.6	0.0	1.6	2.25	H
		BA	80.0	80.0			0.0	24.0	16.0	24.0	16.0	0.0	16.0		
	16	TA	148.3	145.9		2.4	148.3	0.0	0.0	0.0	0.0	0.0	0.0	0.00	O
		BA	220.0	200.0		20.0	220.0	0.0	0.0	0.0	0.0	0.0	0.0		
	17	TA	139.2	118.5		20.7	20.7	118.5	0.0	0.0	0.0	0.0	0.0	0.85	L
		BA	160.0	140.0		20.0	20.0	140.0	0.0	0.0	0.0	0.0	0.0		
	18	TA	62.8	20.7	19.9	22.2	22.2	20.7	0.0	8.4	11.4	0.0	11.4	1.44	M
		BA	112.0	56.0	32.0	24.0	24.0	56.0	0.0	16.0	16.0	0.0	16.0		
	19	TA	126.3	89.3		37.0	37.0	13.4	3.6	4.4	67.9	32.7	35.2	2.41	H
		BA	112.0	104.0		8.0	8.0	24.0	8.0	8.0	64.0	8.0	56.0		
	20	TA	52.3	46.6		5.7	5.7	0.0	0.0	0.0	46.6	0.0	46.6	3.56	VH
		BA	56.0	48.0		8.0	8.0	0.0	0.0	0.0	48.0	0.0	48.0		

[a] Trees display no evidence of defoliation.
[b] Trees which display defoliation ranging from > 0 to < 25 percent defoliation of total needle complement.
[c] Trees which display defoliation ranging from ≥ 25 to < 75 percent defoliation of total needle complement.
[d] Trees which display defoliation ranging from ≥ 75 to < 90 percent defoliation of total needle complement.
[e] Trees which display defoliation ranging from ≥ 90 to 100 percent defoliation of total needle complement.
[f] Trees <9" d.b.h. which display defoliation ranging from ≥ 90 to 100 percent defoliation of total needle complement.
[g] Trees ≥9" d.b.h. which display defoliation ranging from ≥ 90 to 100 percent defoliation of total needle complement.
[h] Damage index = 0 (No/Total TA) + 1 (Light/Total TA) + 2 (Mod./Total TA) + 3 (Heavy/Total TA) + 4 (V. Heavy/Total TA).
[i] Damage Class 0 = 0.0, L = >0.0 - 1.00, M = >1.00 - 2.00, H = >2.00 - 2.80, VH = >2.80 - 4.00

Table 6.--Mean stocking levels for host and non-host tree species greater than 5 inches d.b.h., stocking levels by defoliation class, stocking levels of precommercial- and commercial-sized trees in the very heavy defoliation class, area damage indices, and area damage classes for sampled areas in the Boise River infestation, Sawtooth and Boise National Forests, 1991.--Continued.

						Individual Tree Defoliation Classes					V. Heavy Class		Area Damage	
Area	Line	Total	DF	SAF	Non-Host	No[a]	Light[b]	Mod.[c]	Heavy[d]	V. Heavy[e]	Pre.[f]	Comm.[g]	Index[h]	Class[i]
North Fork Lime Creek														
2	TA	240.9	230.1	10.8		14.0	126.6	90.1	10.2	0.0	0.0	0.0	1.40	M
	BA	240.0	220.0	20.0		20.0	60.0	140.0	20.0	0.0	0.0	0.0		
3	TA	59.3	39.6		19.7	19.7	11.3	4.3	8.0	16.0	0.0	16.0	1.80	M
	BA	130.0	110.0		20.0	20.0	20.0	20.0	20.0	50.0	0.0	50.0		
4	TA	244.6	229.9		14.7	14.7	13.5	80.5	34.8	101.1	90.4	10.7	2.78	H
	BA	152.0	144.0		8.0	8.0	16.0	64.0	32.0	32.0	16.0	16.0		
6	TA	106.9	106.9			0.0	106.9	0.0	0.0	0.0	0.0	0.0	1.00	L
	BA	80.0	80.0			0.0	80.0	0.0	0.0	0.0	0.0	0.0		
7	TA	152.9	152.9			0.0	152.9	0.0	0.0	0.0	0.0	0.0	1.00	L
	BA	140.0	140.0			0.0	140.0	0.0	0.0	0.0	0.0	0.0		
Abbot Gulch														
12	TA	224.8	218.2		6.6	224.8	0.0	0.0	0.0	0.0	0.0	0.0	0.00	O
	BA	140.0	120.0		20.0	140.0	0.0	0.0	0.0	0.0	0.0	0.0		
21	TA	71.8	69.0		2.8	2.8	2.7	10.5	0.0	55.7	24.7	30.9	3.44	VH
	BA	96.0	88.0		8.0	8.0	8.0	24.0	0.0	56.0	8.0	48.0		
22	TA	193.8	134.5		59.3	59.3	134.5	0.0	0.0	0.0	0.0	0.0	0.69	L
	BA	180.0	140.0		40.0	40.0	140.0	0.0	0.0	0.0	0.0	0.0		
West Fork Kelley Creek														
5	TA	102.2	96.9		6.4	6.4	16.4	19.8	0.0	65.5	0.0	65.5	3.10	VH
	BA	120.0	112.0		8.0	8.0	24.0	32.0	0.0	64.0	0.0	64.0		
8	TA	148.2	148.2			0.0	59.1	20.2	0.0	43.8	0.0	43.8	1.86	M
	BA	152.0	152.0			0.0	56.0	24.0	0.0	40.0	0.0	40.0		
9	TA	264.7	264.7			131.0	133.7	0.0	0.0	0.0	0.0	0.0	0.51	L
	BA	120.0	120.0			80.0	40.0	0.0	0.0	0.0	0.0	0.0		

[a] Trees display no evidence of defoliation.
[b] Trees which display defoliation ranging from > 0 to < 25 percent defoliation of total needle complement.
[c] Trees which display defoliation ranging from ≥ 25 to < 75 percent defoliation of total needle complement.
[d] Trees which display defoliation ranging from ≥ 75 to < 90 percent defoliation of total needle complement.
[e] Trees which display defoliation ranging from ≥ 90 to 100 percent defoliation of total needle complement.
[f] Trees <9" d.b.h. which display defoliation ranging from ≥ 90 to 100 percent defoliation of total needle complement.
[g] Trees ≥9" d.b.h. which display defoliation ranging from ≥ 90 to 100 percent defoliation of total needle complement.
[h] Damage index = 0 (No/Total TA) + 1 (Light/Total TA) + 2 (Mod./Total TA) + 3 (Heavy/Total TA) + 4 (V. Heavy/Total TA).
[i] Damage Class O = 0.0, L = >0.0 - 1.00, M = >1.00 - 2.00, H = >2.00 - 2.80, VH = >2.80 - 4.00

Table 6.--Mean stocking levels for host and non-host tree species greater than 5 inches d.b.h., stocking levels by defoliation class, stocking levels of precommercial- and commercial-sized trees in the very heavy defoliation class, area damage indices, and area damage classes for sampled areas in the Boise River infestation, Sawtooth and Boise National Forests, 1991.--Continued.

						Individual Tree Defoliation Classes					V. Heavy Class		Area Damage	
Area	Line	Total	DF	SAF	Non-Host	No[a]	Light[b]	Mod.[c]	Heavy[d]	V. Heavy[e]	Pre.[f]	Comm.[g]	Index[h]	Class[i]
Virginia Gulch														
	11 TA	64.8	10.4		54.4	64.8	0.0	0.0	0.0	0.0	0.0	0.0	0.00	O
	BA	180.0	20.0		160.0	180.0	0.0	0.0	0.0	0.0	0.0	0.0		
Gardner Gulch														
	10 TA	51.5	51.5			0.0	51.5	0.0	0.0	0.0	0.0	0.0	1.00	L
	BA	40.0	40.0			0.0	40.0	0.0	0.0	0.0	0.0	0.0		
Elk Creek														
	1 TA	42.4	25.3	17.0		0.0	1.2	19.1	0.0	22.1	0.0	22.1	3.01	VH
	BA	104.0	72.0	32.0		0.0	8.0	40.0	0.0	56.0	0.0	56.0		
	2 TA	178.6	178.6			0.0	36.7	50.2	22.6	69.1	0.0	69.1	2.72	H
	BA	256.0	256.0			0.0	56.0	80.0	40.0	80.0	0.0	80.0		
	3 TA	50.4	49.5		0.9	0.9	0.0	8.6	6.5	34.4	0.0	34.4	3.45	VH
	BA	136.0	128.0		8.0	8.0	0.0	24.0	16.0	88.0	0.0	88.0		
	4 TA	152.0	101.7		50.3	56.2	9.4	0.7	3.9	81.8	19.0	62.8	2.30	H
	BA	200.0	168.0		32.0	48.0	8.0	8.0	8.0	128.0	8.0	120.0		
Phifer Creek														
	1 TA	168.1	141.3		26.8	26.8	68.9	72.4	0.0	0.0	0.0	0.0	1.27	M
	BA	144.0	120.0		24.0	24.0	80.0	40.0	0.0	0.0	0.0	0.0		

[a] Trees display no evidence of defoliation.
[b] Trees which display defoliation ranging from > 0 to < 25 percent defoliation of total needle complement.
[c] Trees which display defoliation ranging from ≥ 25 to < 75 percent defoliation of total needle complement.
[d] Trees which display defoliation ranging from ≥ 75 to < 90 percent defoliation of total needle complement.
[e] Trees which display defoliation ranging from ≥ 90 to 100 percent defoliation of total needle complement.
[f] Trees <9" d.b.h. which display defoliation ranging from ≥ 90 to 100 percent defoliation of total needle complement.
[g] Trees ≥9" d.b.h. which display defoliation ranging from ≥ 90 to 100 percent defoliation of total needle complement.
[h] Damage index = 0 (No/Total TA) + 1 (Light/Total TA) + 2 (Mod./Total TA) + 3 (Heavy/Total TA) + 4 (V. Heavy/Total TA).
[i] Damage Class O = 0.0, L = >0.0 - 1.00, M = >1.00 - 2.00, H = >2.00 - 2.80, VH = >2.80 - 4.00

Table 7.--Mortality scenarios for the Boise River infestation, Sawtooth and Boise National Forests, 1991.

Size Classes	Area Damage Classes		
	Moderate[a]	Heavy[a]	Very Heavy[a]
Precommercial[b]			
TA (>90 % defoliation)	0.0	28.4	4.9
TA (25 % mortality level)	0.0	7.1	1.2
TA (40 % mortality level)	0.0	11.4	2.0
TA (70 % mortality level)	0.0	19.9	3.5
TA (95 % mortality level)	0.0	27.0	4.7
Commercial[c]			
TA (>90 % defoliation)	10.2	35.9	39.9
TA (25 % mortality level)	2.5	9.0	10.0
TA (40 % mortality level)	4.1	14.4	16.0
TA (70 % mortality level)	7.1	25.1	27.9
TA (95 % mortality level)	9.7	34.1	37.9

[a] Area damage classes taken from Table 6.
[b] Precommercial designates trees per acre with d.b.h. >5" and <9".
[c] Commercial designates trees per acre with d.b.h. $\geq$ 9".
Means are calculated from the following areas: Marsh Creek, North Fork Lime Creek, Abbot Gulch, West Fork Kelley Creek, Virginia Gulch, and Gardner Gulch, Sawtooth National Forest; Elk Creek and Phifer Creek, Boise National Forest.

Table 8.--Mean stocking levels for host trees greater than 5 inches d.b.h. by individual tree defoliation classes and number of trees per acre predicted to be top-killed within 4 years after initial defoliation in sample areas within the Boise River infestation, Sawtooth and Boise National Forests, 1991.

Area	Line	Area Damage Class[a]	Individual Tree Defoliation Classes										Top-kill (Trees/AC)	
			DF (Trees/AC)					TF (Trees/AC)						
			0[b]	Light[c]	Mod.[d]	Heavy[e]	V. Heavy[f]	0	Light	Mod.	Heavy	V. Heavy	DF	TF
Marsh Creek														
	1	M	0.0	76.6	148.3	48.4	0.0	0.0	0.0	0.0	0.0	0.0	42.9	0.0
	13	M	0.0	82.4	33.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.9	0.0
	14	M	3.2	14.1	2.9	40.7	0.0	0.0	0.0	0.0	0.0	0.0	11.2	0.0
	15	H	0.0	8.5	5.3	11.5	1.6	0.0	0.0	0.0	0.0	0.0	4.4	0.0
	16	O	145.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	17	L	0.0	118.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.1	0.0
	18	M	0.0	20.7	0.0	0.0	0.0	0.0	0.0	0.0	8.5	11.4	1.2	1.8
	19	H	0.0	13.4	3.6	4.4	67.9	0.0	0.0	0.0	0.0	0.0	7.8	0.0
	20	VH	0.0	0.0	0.0	0.0	46.6	0.0	0.0	0.0	0.0	0.0	3.6	0.0
North Fork Lime Creek														
	2	M	14.0	126.6	79.3	10.2	0.0	0.0	0.0	10.8	0.0	0.0	24.3	1.4
	3	M	0.0	11.3	4.3	8.0	16.0	0.0	0.0	0.0	0.0	0.0	4.6	0.0
	4	H	0.0	13.5	80.5	34.8	101.1	0.0	0.0	0.0	0.0	0.0	31.5	0.0
	6	L	0.0	106.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.4	0.0
	7	L	0.0	152.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.2	0.0
Abbot Gulch														
	12	O	218.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	21	VH	0.0	2.7	10.5	0.0	55.7	0.0	0.0	0.0	0.0	0.0	6.4	0.0
	22	L	0.0	134.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.1	0.0
West Fork Kelley Creek														
	5	VH	0.0	16.4	19.8	0.0	60.6	0.0	0.0	0.0	0.0	0.0	9.3	0.0
	8	M	0.0	59.1	20.2	25.1	43.8	0.0	0.0	0.0	0.0	0.0	16.6	0.0
	9	L	78.8	133.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.0	0.0
Virginia Gulch														
	11	O	10.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gardner Gulch														
	10	L	0.0	51.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.1	0.0

[a] Area defoliation class taken from the damage index column of table 6; O = no defoliation, L = light defoliation, M = moderate defoliation, H = heavy defoliation, VH = very heavy defoliation.

[b] O = no defoliation

[c] Light ranges from >0 to <25 percent defoliation of total needle complement.

[d] Mod. ranges from ≥25 to <75 percent defoliation of total needle complement.

[e] Heavy ranges from ≥75 to <90 percent defoliation of total needle complement.

[f] V. Heavy ranges from ≥90 to 100 percent defoliation of total needle complement.

Table 8.--Mean stocking levels for host trees greater than 5 inches d.b.h. by individual tree defoliation classes and number of trees per acre predicted to be top-killed within 4 years after initial defoliation in sample areas within the Boise River infestation, Sawtooth and Boise National Forests, 1991.--Continued.

Area	Line	Area Damage Class[a]	Individual Tree Defoliation Classes										Top-kill (Trees/AC)	
			DF (Trees/AC)					TF (Trees/AC)						
			0[b]	Light[c]	Mod.[d]	Heavy[e]	V. Heavy[f]	0	Light	Mod.	Heavy	V. Heavy	DF	TF
Elk Creek														
	1	VH	0.0	0.0	11.4	0.0	14.0	0.0	1.2	7.7	0.0	8.1	3.1	3.2
	2	H	0.0	36.7	50.2	22.6	69.1	0.0	0.0	0.0	0.0	0.0	22.1	0.0
	3	VH	0.0	0.0	8.6	6.5	34.4	0.0	0.0	0.0	0.0	0.0	5.8	0.0
	4	H	0.0	9.4	0.7	3.9	81.8	0.0	0.0	0.0	0.0	0.0	8.0	0.0
Phifer Creek														
	1	M	0.0	68.9	72.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.2	0.0

[a] Area defoliation class taken from the damage index column of table 6; 0 = no defoliation, L = light defoliation, M = moderate defoliation, H = heavy defoliation, VH = very heavy defoliation.
[b] 0 = no defoliation
[c] Light ranges from >0 to <25 percent defoliation of total needle complement.
[d] Mod. ranges from ≥25 to <75 percent defoliation of total needle complement.
[e] Heavy ranges from ≥75 to <90 percent defoliation of total needle complement.
[f] V. Heavy ranges from ≥90 to 100 percent defoliation of total needle complement.

Table 9.--Top-kill scenarios for the Boise River infestation, Sawtooth and Boise National Forests, 1991.

	Area Damage Classes							
	Light[a]		Moderate[a]		Heavy[a]		V. Heavy[a]	
	DF	TF	DF	TF	DF	TF	DF	TF
Trees/AC	7.0	0.0	16.1	0.4	14.8	0.0	5.6	0.6

[a] Area damage classes taken from Table 6.
Means are calculated from the following areas: Marsh Creek, North Fork Lime Creek, Abbot Gulch, West Fork Kelley Creek, Virginia Gulch, and Gardner Gulch, Sawtooth National Forest; Elk Creek and Phifer Creek, Boise National Forest.

Table 10.--Predicted early larval densities for 1992 based upon cocoon sampling conducted in 1991 from areas with no or only light defoliation within the Boise River infestation, Sawtooth National Forest, 1991.

Area	Line	Actual 1991 cocoons/1000 sq. in.	Actual[a] Def. Class.	Predicted[b] 1992 larvae/1000 sq. in.	Predicted[c] Def. Class.
Marsh Creek					
	16	0.64	0	41.97	L - M
	17	2.68	L	172.32	VH
North Fork Lime Creek					
	6	3.96	L	254.11	VH
	7	3.04	L	195.33	VH
Abbot Gulch					
	12	0.04	0	3.63	0
	22	5.06	L	324.40	VH
West Fork Kelley Creek					
	9	2.54	L	163.38	VH
Virginia Gulch					
	11	0.20	0	13.85	0
Gardner Gulch					
	10	0.56	L	36.85	L - M

[a] Area damage classes taken from Table 6.

[b] Predictions calculated from the regression equation, Y = 1.07 + 63.9 (X) where X = number of pupal cocoons per 1,000 square inches of foliage in 1991 and Y = number of early larvae per 1,000 square inches of foliage predicted in 1992.

[c] No defoliation, light to moderate defoliation, heavy defoliation and very heavy defoliation is predicted for 1992 when larval populations average <20 larvae, 20 to 49 larvae, 50 to 99 larvae, and >99 larvae per 1,000 square inches of foliage.

Table 11.--Predicted egg mass sizes (eggs per mass) estimated from samples taken in defoliated and non-defoliated areas within the Boise River, Sagehen/Squaw Creek, and Mann Creek/Brownlee Creek infestations; and within Sunset Mountain and Bald Mountain, 1991.

Infestation		Defoliated	Non-defoliated	Combined
Boise River				
	n[a]	149	77	226
	x[b]	131	154	139
	SD[c]	44	38	43
Sagehen/Squaw Creek				
	n	79	20	99
	x	145	161	148
	SD	45	32	43
Mann Creek/Brownlee Creek				
	n	18	27	45
	x	144	183	167
	SD	54	38	49
Sunset Mountain				
	n	0	39	39
	x	0	134	134
	SD	0	31	31
Bald Mountain				
	n	0	60	60
	x	0	133	133
	SD	0	38	38

[a] n = number of egg masses.
[b] x = mean number of eggs per mass.
[c] SD = standard deviation.

Table 12.--Mean stocking levels for host and non-host tree species greater than 5 inches d.b.h., stocking levels by defoliation class, stocking levels of precommercial- and commercial-sized trees in the very heavy defoliation class, area damage indices, and area damage classes for sampled areas in the Sagehen/Squaw Creek infestation, Boise National Forest, 1991.

								Individual Tree Defoliation Classes					V. Heavy Class		Area Damage	
Area	Line		Total	DF	GF	SAF	S	Non-Host	No[a]	Light[b]	Mod.[c]	Heavy[d]	V. Heavy[e]	Pre-comm.[f]	Comm.[g]	Index[h]	Class[i]
Sagehen																	
	1	TA	102.2	19.6	73.9		4.2	4.5	11.9	75.1	15.3	0.0	0.0	0.0	0.0	1.03	L
		BA	96.0	16.0	64.0		8.0	8.0	24.0	56.0	16.0	0.0	0.0	0.0	0.0		
	2	TA	72.0	4.7	53.7		13.6	0.0	0.0	23.5	48.5	0.0	0.0	0.0	0.0	1.68	M
		BA	88.0	16.0	64.0		8.0	0.0	0.0	40.0	48.0	0.0	0.0	0.0	0.0		
	3	TA	219.7	6.9	211.8			1.0	1.0	32.0	106.9	31.7	48.0	38.1	9.9	2.42	H
		BA	128.0	8.0	112.0			8.0	8.0	16.0	80.0	8.0	16.0	8.0	8.0		
	4	TA	95.6	23.3	72.3				0.0	0.0	50.9	30.8	13.9	0.0	13.9	2.60	H
		BA	72.0	16.0	56.0				0.0	0.0	48.0	8.0	16.0	0.0	16.0		
	5	TA	120.6	6.5	106.0			8.1	8.1	112.5	0.0	0.0	0.0	0.0	0.0	0.93	L
		BA	128.0	16.0	88.0			24.0	24.0	104.0	0.0	0.0	0.0	0.0	0.0		
2nd Fork																	
	1	TA	125.6	5.6	120.0				0.0	0.0	48.0	63.0	14.6	0.0	14.6	2.72	H
		BA	128.0	40.0	88.0				0.0	0.0	72.0	16.0	40.0	0.0	40.0		
	2	TA	202.6		196.4			6.2	6.2	39.4	157.0	0.0	0.0	0.0	0.0	1.74	M
		BA	144.0		120.0			24.0	24.0	8.0	112.0	0.0	0.0	0.0	0.0		
	3	TA	33.1		33.1				0.0	0.0	2.7	17.5	12.8	0.0	12.8	3.30	VH
		BA	72.0		72.0				0.0	0.0	8.0	40.0	24.0	0.0	24.0		
3rd Fork																	
	1	TA	127.5		76.2			51.2	51.2	0.0	49.5	26.7	0.0	0.0	0.0	1.41	M
		BA	112.0		80.0			32.0	32.0	0.0	64.0	16.0	0.0	0.0	0.0		
	2	TA	121.5	3.3	116.0	2.2			0.0	5.7	26.5	14.8	74.5	45.2	29.3	3.08	VH
		BA	184.0	16.0	160.0	8.0			0.0	24.0	80.0	32.0	48.0	8.0	40.0		
	3	TA	103.4	9.7	87.6		2.7	3.4	3.4	0.0	72.6	71.0	20.3	0.0	0.0	2.40	H
		BA	144.0	40.0	80.0		8.0	16.0	16.0	0.0	104.0	16.1	8.0	0.0	0.0		
	4	TA	183.3	7.5	150.8			25.0	25.0	0.0	11.5	4.2	142.6	91.5	51.1	3.29	VH
		BA	176.0	8.0	104.0			64.0	64.0	0.0	8.0	8.0	96.0	24.0	72.0		

a Trees display no evidence of defoliation.
b Trees which display defoliation ranging from > 0 to < 25 percent defoliation of total needle complement.
c Trees which display defoliation ranging from ≥ 25 to < 75 percent defoliation of total needle complement.
d Trees which display defoliation ranging from ≥ 75 to < 90 percent defoliation of total needle complement.
e Trees which display defoliation ranging from ≥ 90 to 100 percent defoliation of total needle complement.
f Trees <9" d.b.h. which display defoliation ranging from ≥ 90 to 100 percent defoliation of total needle complement.
g Trees ≥9" d.b.h. which display defoliation ranging from ≥ 90 to 100 percent defoliation of total needle complement.
h Damage index = 0 (No/Total TA) + 1 (Light/Total TA) + 2 (Mod./Total TA) + 3 (Heavy/Total TA) + 4 (V. Heavy/Total TA).
i Damage Class 0 = 0.0, L = >0.0 - 1.00, M = >1.00 - 2.00, H = >2.00 - 2.80, VH = >2.80 - 4.00

Table 13.--Mortality scenarios for the Sagehen/Squaw Creek infestation, Boise National Forests, 1991.

Size Classes	Area Damage Classes		
	Moderate[a]	Heavy[a]	Very Heavy[a]
Precommercial[b]			
TA (>90 % defoliation)	0.0	9.5	45.6
TA (25 % mortality level)	0.0	2.4	11.4
TA (40 % mortality level)	0.0	3.8	18.2
TA (70 % mortality level)	0.0	6.7	31.9
TA (95 % mortality level)	0.0	9.1	43.3
Commercial[c]			
TA (>90 % defoliation)	0.0	9.6	31.1
TA (25 % mortality level)	0.0	2.4	7.8
TA (40 % mortality level)	0.0	3.8	12.4
TA (70 % mortality level)	0.0	6.7	21.8
TA (95 % mortality level)	0.0	9.1	29.5

[a] Area damage classes taken from Table 12.
[b] Precommercial designates trees per acre with d.b.h. >5" and <9".
[c] Commercial designates trees per acre with d.b.h. $\geq$ 9".
Means are calculated from the following areas: Sagehen, 2nd Fork, and 3rd Fork, Boise National Forest.

Table 14.--Mean stocking levels for host trees greater than 5 inches d.b.h. by individual tree defoliation classes and number of trees per acre predicted to be top-killed within 4 years after initial defoliation in sample areas within the Sagehen/Squaw Creek infestation, Boise National Forests, 1991.

Area	Line	Area Damage Class[a]	Individual Tree Defoliation Classes										Top-kill (Trees/AC)	
			DF (Trees/AC)					TF (Trees/AC)						
			0[b]	Light[c]	Mod.[d]	Heavy[e]	V. Heavy[f]	0	Light	Mod.	Heavy	V. Heavy	DF	TF
Sagehen														
	1	L	0.0	19.6	0.0	0.0	0.0	3.2	55.5	15.3	0.0	0.0	1.2	3.7
	2	M	0.0	4.7	0.0	0.0	0.0	0.0	5.3	48.5	0.0	0.0	0.3	6.5
	3	H	0.0	0.0	6.9	0.0	0.0	0.0	32.0	100.0	31.7	48.0	1.2	28.4
	4	H	0.0	0.0	23.3	0.0	0.0	0.0	0.0	27.6	30.8	13.9	4.2	12.3
	5	L	0.0	6.5	0.0	0.0	0.0	0.0	106.0	0.0	0.0	0.0	0.4	3.2
2nd Fork														
	1	H	0.0	0.0	2.9	1.2	1.5	0.0	0.0	45.1	1.8	13.1	0.9	8.4
	2	M	0.0	0.0	0.0	0.0	0.0	0.0	39.4	157.0	0.0	0.0	0.0	21.6
	3	VH	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.7	17.5	12.8	0.0	6.1
3rd Fork														
	1	M	0.0	0.0	0.0	0.0	0.0	0.0	0.0	49.5	26.7	0.0	0.0	12.1
	2	VH	0.0	3.3	0.0	0.0	0.0	0.0	2.4	26.5	14.8	74.5	0.2	18.7
	3	H	0.0	0.0	7.8	1.9	0.0	0.0	0.0	62.1	5.2	20.3	1.9	12.5
	4	VH	0.0	0.0	0.0	0.0	7.5	0.0	0.0	11.5	4.2	135.1	0.6	24.3

[a] Area defoliation class taken from the damage index column of table 12; 0 = no defoliation, L = light defoliation, M = moderate defoliation, H = heavy defoliation, VH = very heavy defoliation.

[b] 0 = no defoliation

[c] Light ranges from >0 to <25 percent defoliation of total needle complement.

[d] Mod. ranges from ≥25 to <75 percent defoliation of total needle complement.

[e] Heavy ranges from ≥75 to <90 percent defoliation of total needle complement.

[f] V. Heavy ranges from ≥90 to 100 percent defoliation of total needle complement.

Table 15.--Top-kill scenarios for the Sagehen/Squaw Creek infestation, Boise National Forests, 1991.

	Area Damage Classes							
	Light[a]		Moderate[a]		Heavy[a]		V. Heavy[a]	
	DF	TF	DF	TF	DF	TF	DF	TF
Trees/AC	0.8	3.5	0.1	13.4	2.1	15.4	0.3	16.4

[a] Area damage classes taken from Table 12.
Means are calculated from the following areas: Sagehen, 2nd Fork, and 3rd Fork, Boise National Forest.

Table 16.--Predicted early larval densities for 1992 based upon cocoon sampling conducted in 1991 from areas with no or only light defoliation in the Sagehen/Squaw Creek infestation, Boise National Forest, 1991.

Area	Line	Actual 1991 cocoons/1000 sq. in.	Actual[a] Def. Class.	Predicted[b] 1992 larvae/1000 sq. in.	Predicted[c] Def. Class.
Sagehen					
	1	3.98	L	255.39	VH
	5	3.20	L	205.55	VH

[a] Area damage classes taken from Table 12.

[b] Predictions calculated from the regression equation, Y = 1.07 + 63.9 (X) where X = number of pupal cocoons per 1,000 square inches of foliage in 1991 and Y = number of early larvae per 1,000 square inches of foliage predicted in 1992.

[c] No defoliation, light to moderate defoliation, heavy defoliation and very heavy defoliation is predicted for 1992 when larval populations average <20 larvae, 20 to 49 larvae, 50 to 99 larvae, and >99 larvae per 1,000 square inches of foliage.

Table 17.--Mean stocking levels for host and non-host tree species greater than 5 inches d.b.h., stocking levels by defoliation class, stocking levels of precommercial- and commercial-sized trees in the very heavy defoliation class, area damage indices, and area damage classes for sampled areas in the Mann Creek/Brownlee Creek infestation, Payette, Boise National Forest, 1991.

								Individual Tree Defoliation Classes					V. Heavy Class		Area Damage	
Area	Line		Total	DF	GF	SAF	S	Non-Host	No[a]	Light[b]	Mod.[c]	Heavy[d]	V. Heavy[e]	Pre-comm.[f]	Comm.[g]	Index[h]	Class[i]
Brownlee																	
	2	TA	122.4	12.7	104.5			5.1	0.0	5.1	107.9	0.0	9.4	0.0	9.4	2.12	H
		BA	120.0	16.0	88.0			16.0	0.0	16.0	96.0	0.0	8.0	0.0	8.0		
	3	TA	104.2	0.0	104.2				0.0	0.0	94.9	1.2	8.0	0.0	8.0	2.17	H
		BA	72.0	0.0	72.0				0.0	0.0	64.0	1.1	6.9	0.0	6.9		
	4	TA	59.9	18.9	31.6			9.3	4.9	10.3	40.3	4.4	0.0	0.0	0.0	1.72	M
		BA	88.0	32.0	32.0			24.0	8.0	32.0	40.0	8.0	0.0	0.0	0.0		
Mann Creek																	
	1	TA	63.2		56.9			6.3	6.3	56.9	0.0	0.0	0.0	0.0	0.0	0.90	L
		BA	140.0		120.0			20.0	20.0	120.0	0.0	0.0	0.0	0.0	0.0		
	5	TA	72.5	9.9	46.3			16.3	26.3	46.3	0.0	0.0	0.0	0.0	0.0	0.64	L
		BA	100.0	20.0	20.0			60.0	80.0	20.0	0.0	0.0	0.0	0.0	0.0		
	6	TA	88.8	73.5				15.3	15.3	73.5	0.0	0.0	0.0	0.0	0.0	0.83	L
		BA	160.0	100.0				60.0	60.0	100.0	0.0	0.0	0.0	0.0	0.0		

[a] Trees display no evidence of defoliation.
[b] Trees which display defoliation ranging from > 0 to < 25 percent defoliation of total needle complement.
[c] Trees which display defoliation ranging from ≥ 25 to < 75 percent defoliation of total needle complement.
[d] Trees which display defoliation ranging from ≥ 75 to < 90 percent defoliation of total needle complement.
[e] Trees which display defoliation ranging from ≥ 90 to 100 percent defoliation of total needle complement.
[f] Trees <9" d.b.h. which display defoliation ranging from ≥ 90 to 100 percent defoliation of total needle complement.
[g] Trees ≥9" d.b.h. which display defoliation ranging from ≥ 90 to 100 percent defoliation of total needle complement.
[h] Damage index = 0 (No/Total TA) + 1 (Light/Total TA) + 2 (Mod./Total TA) + 3 (Heavy/Total TA) + 4 (V. Heavy/Total TA).
[i] Damage Class 0 = 0.0, L = >0.0 - 1.00, M = >1.00 - 2.00, H = >2.00 - 2.80, VH = >2.80 - 4.00

Table 18.--Mortality scenarios for the Mann Creek/Brownlee Creek infestation, Payette National Forests, 1991.

Size Classes	Area Damage Classes		
	Moderate[a]	Heavy[a]	Very Heavy[a]
Precommercial[b]			
TA (>90 % defoliation)	0.0	0.0	0.0
TA (25 % mortality level)	0.0	0.0	0.0
TA (40 % mortality level)	0.0	0.0	0.0
TA (70 % mortality level)	0.0	0.0	0.0
TA (95 % mortality level)	0.0	0.0	0.0
Commercial[c]			
TA (>90 % defoliation)	0.0	8.7	0.0
TA (25 % mortality level)	0.0	2.2	0.0
TA (40 % mortality level)	0.0	3.5	0.0
TA (70 % mortality level)	0.0	6.1	0.0
TA (95 % mortality level)	0.0	8.3	0.0

[a] Area damage classes taken from Table 17.
[b] Precommercial designates trees per acre with d.b.h. >5" and <9".
[c] Commercial designates trees per acre with d.b.h. ≥ 9".
Means are calculated from the following areas: Mann Creek, Brownlee Creek, and Pine Creek, Payette National Forest.

Table 19.--Mean stocking levels for host trees greater than 5 inches d.b.h. by individual tree defoliation classes and number of trees per acre predicted to be top-killed within 4 years after initial defoliation in sample areas within the Mann Creek/Brownlee Creek infestation, Payette National Forest, 1991.

Area	Line	Area Damage Class[a]	Individual Tree Defoliation Classes										Top-kill (Trees/AC)	
			DF (Trees/AC)					TF (Trees/AC)						
			0[b]	Light[c]	Mod.[d]	Heavy[e]	V. Heavy[f]	0	Light	Mod.	Heavy	V. Heavy	DF	TF
Brownlee														
	2	H	0.0	0.0	12.7	0.0	0.0	0.0	0.0	95.1	0.0	9.4	2.3	14.9
	3	H	0.0	0.0	0.0	0.0	0.0	0.0	0.0	94.9	1.2	8.0	0.0	14.8
	4	M	0.0	2.5	12.0	4.4	0.0	0.0	3.3	28.3	0.0	0.0	3.4	3.8
Mann Creek														
	1	L	0.0	0.0	0.0	0.0	0.0	0.0	56.9	0.0	0.0	0.0	0.0	1.7
	5	L	9.9	0.0	0.0	0.0	0.0	0.0	46.3	0.0	0.0	0.0	0.0	1.4
	6	L	0.0	73.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.4	0.0

[a] Area defoliation class taken from the damage index column of table 17; 0 = no defoliation, L = light defoliation, M = moderate defoliation, H = heavy defoliation, VH = very heavy defoliation.

[b] 0 = no defoliation

[c] Light ranges from >0 to <25 percent defoliation of total needle complement.

[d] Mod. ranges from ≥25 to <75 percent defoliation of total needle complement.

[e] Heavy ranges from ≥75 to <90 percent defoliation of total needle complement.

[f] V. Heavy ranges from ≥90 to 100 percent defoliation of total needle complement.

Table 20.--Top-kill scenarios for the Mann Creek/Brownlee Creek infestation, Payette National Forests, 1991.

	Area Damage Classes							
	Light[a]		Moderate[a]		Heavy[a]		V. Heavy[a]	
	DF	TF	DF	TF	DF	TF	DF	TF
Trees/AC	1.5	1.0	3.4	3.8	1.2	14.8	0.0	0.0

[a] Stand damage classes taken from Table 17.
Means are calculated from the following areas: Mann Creek, Brownlee Creek, and Pine Creek, Payette National Forest.

Table 21.--Predicted early larval densities for 1992 based upon cocoon sampling conducted in 1991 from areas with no or only light defoliation in the Mann Creek/Brownlee Creek infestation, Payette National Forest, 1991.

Area	Line	Actual 1991 cocoons/1000 sq. in.	Actual[a] Def. Class.	Predicted[b] 1992 larvae/1000 sq. in.	Predicted[c] Def. Class.
Mann Creek					
	1	2.40	L	154.43	VH
	5	0.34	L	22.80	L - M
	6	1.68	L	108.42	VH

[a] Area damage classes taken from Table 17.

[b] Predictions calculated from the regression equation, Y = 1.07 + 63.9 (X) where X = number of pupal cocoons per 1,000 square inches of foliage in 1991 and Y = number of early larvae per 1,000 square inches of foliage predicted in 1992.

[c] No defoliation, light to moderate defoliation, heavy defoliation and very heavy defoliation is predicted for 1992 when larval populations average <20 larvae, 20 to 49 larvae, 50 to 99 larvae, and >99 larvae per 1,000 square inches of foliage.

Table 22.--Mean stocking levels for host and non-host tree species greater than 5 inches d.b.h., stocking levels by defoliation class, stocking levels of precommercial- and commercial-sized trees in the very heavy defoliation class, area damage indices, and area damage classes for sampled areas on Bald Mountain, Sawtooth National Forest and Bureau of Land Management, 1991.

						Individual Tree Defoliation Classes					V. Heavy Class		Area Damage	
Area	Line	Total	DF	SAF	Non-Host	No[a]	Light[b]	Mod.[c]	Heavy[d]	V. Heavy[e]	Pre.[f]	Comm.[g]	Index[h]	Class[i]
Cold Springs														
	6 TA	442.1	442.1			442.1	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0
	BA	220.0	220.0			220.0	0.0	0.0	0.0	0.0	0.0	0.0		
	7 TA	34.6	34.6			31.6	3.0	0.0	0.0	0.0	0.0	0.0	0.09	L
	BA	100.0	100.0			80.0	20.0	0.0	0.0	0.0	0.0	0.0		
	8 TA	102.8	102.8			102.8	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0
	BA	180.0	180.0			180.0	0.0	0.0	0.0	0.0	0.0	0.0		
River Run														
	9 TA	66.7	66.7			66.7	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0
	BA	180.0	180.0			180.0	0.0	0.0	0.0	0.0	0.0	0.0		
	10 TA	92.9	92.9			89.0	3.9	0.0	0.0	0.0	0.0	0.0	0.04	L
	BA	160.0	160.0			140.0	20.0	0.0	0.0	0.0	0.0	0.0		
	11 TA	219.4	219.4			219.4	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0
	BA	180.0	180.0			180.0	0.0	0.0	0.0	0.0	0.0	0.0		
	12 TA	89.3	89.3			89.3	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0
	BA	80.0	80.0			80.0	0.0	0.0	0.0	0.0	0.0	0.0		
Warm Springs														
	1 TA	400.1	0.0	400.1		400.1	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0
	BA	160.0	0.0	160.0		160.0	0.0	0.0	0.0	0.0	0.0	0.0		
	2 TA	235.7	177.2	58.6		235.7	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0
	BA	300.0	240.0	60.0		300.0	0.0	0.0	0.0	0.0	0.0	0.0		
	3 TA	191.4	163.2	28.2		191.4	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0
	BA	140.0	120.0	20.0		140.0	0.0	0.0	0.0	0.0	0.0	0.0		
	4 TA	382.4	382.4			44.0	338.4	0.0	0.0	0.0	0.0	0.0	0.88	L
	BA	140.0	140.0			60.0	80.0	0.0	0.0	0.0	0.0	0.0		
	5 TA	210.3	210.3			52.1	158.2	0.0	0.0	0.0	0.0	0.0	0.75	L
	BA	200.0	200.0			80.0	120.0	0.0	0.0	0.0	0.0	0.0		

[a] Trees display no evidence of defoliation.
[b] Trees which display defoliation ranging from > 0 to < 25 percent defoliation of total needle complement.
[c] Trees which display defoliation ranging from ≥ 25 to < 75 percent defoliation of total needle complement.
[d] Trees which display defoliation ranging from ≥ 75 to < 90 percent defoliation of total needle complement.
[e] Trees which display defoliation ranging from ≥ 90 to 100 percent defoliation of total needle complement.
[f] Trees <9" d.b.h. which display defoliation ranging from ≥ 90 to 100 percent defoliation of total needle complement.
[g] Trees ≥9" d.b.h. which display defoliation ranging from ≥ 90 to 100 percent defoliation of total needle complement.
[h] Damage index = 0 (No/Total TA) + 1 (Light/Total TA) + 2 (Mod./Total TA) + 3 (Heavy/Total TA) + 4 (V. Heavy/Total TA).
[i] Damage Class 0 = 0.0, L = >0.0 - 1.00, M = >1.00 - 2.00, H = >2.00 - 2.80, VH = >2.80 - 4.00

Table 23.--Predicted early larval densities for 1992 based upon cocoon sampling conducted in 1991 from areas with no or only light defoliation on Bald Mountain, Sawtooth National Forest and Bureau of Land Management, 1991.

Area	Line	Actual 1991 cocoons/1000 sq. in.	Actual[a] Def. Class.	Predicted[b] 1992 larvae/1000 sq. in.	Predicted[c] Def. Class.
Cold Springs					
	6	0.18	0	12.57	0
	7	0.98	L	63.69	H
	8	0.54	0	35.58	L - M
River Run					
	9	0.24	0	16.41	0
	10	0.28	L	18.96	0
	11	0.18	0	12.57	0
	12	0.00	0	0.00	0
Warm Springs					
	1	0.00	0	0.00	0
	2	0.00	0	0.00	0
	3	0.00	0	0.00	0
	4	0.16	L	11.29	0
	5	3.38	L	217.05	VH

[a] Area damage classes taken from Table 22.

[b] Predictions calculated from the regression equation, $Y = 1.07 + 63.9 (X)$ where X = number of pupal cocoons per 1,000 square inches of foliage in 1991 and Y = number of early larvae per 1,000 square inches of foliage predicted in 1992.

[c] No defoliation, light to moderate defoliation, heavy defoliation and very heavy defoliation is predicted for 1992 when larval populations average <20 larvae, 20 to 49 larvae, 50 to 99 larvae, and >99 larvae per 1,000 square inches of foliage.

Table 24.--Mean stocking levels for host and non-host tree species greater than 5 inches d.b.h., stocking levels by defoliation class, stocking levels of precommercial- and commercial-sized trees in the very heavy defoliation class, area damage indices, and area damage classes for sampled areas on Bogus Basin and Sunset Mountain, Boise National Forest, 1991.

						Individual Tree Defoliation Classes					V. Heavy Class		Area Damage	
Area	Line	Total	DF	SAF	Non-Host	No[a]	Light[b]	Mod.[c]	Heavy[d]	V. Heavy[e]	Pre.[f]	Comm.[g]	Index[h]	Class[i]
Bogus Basin														
1	TA	54.9	43.7		11.2	54.9	0.0	0.0	0.0	0.0	0.0	0.0	0.00	O
	BA	140.0	120.0		20.0	140.0	0.0	0.0	0.0	0.0	0.0	0.0		
Sunset Mountain														
1	TA	17.0	17.0			0.0	17.0	0.0	0.0	0.0	0.0	0.0	1.00	L
	BA	40.0	40.0			0.0	40.0	0.0	0.0	0.0	0.0	0.0		
2	TA	154.8	29.0	125.8		154.8	0.0	0.0	0.0	0.0	0.0	0.0	0.00	O
	BA	80.0	60.0	20.0		80.0	0.0	0.0	0.0	0.0	0.0	0.0		
3	TA	98.1	98.1			98.1	0.0	0.0	0.0	0.0	0.0	0.0	0.00	O
	BA	160.0	160.0			160.0	0.0	0.0	0.0	0.0	0.0	0.0		
4	TA	107.0	41.1	65.9		5.8	77.7	23.5	0.0	0.0	0.0	0.0	1.17	M
	BA	160.0	120.0	40.0		20.0	120.0	20.0	0.0	0.0	0.0	0.0		
5	TA	27.9	24.3	3.6		27.9	0.0	0.0	0.0	0.0	0.0	0.0	0.00	O
	BA	80.0	60.0	20.0		80.0	0.0	0.0	0.0	0.0	0.0	0.0		
6	TA	59.2	47.7	11.5		0.0	59.2	0.0	0.0	0.0	0.0	0.0	1.00	L
	BA	180.0	140.0	40.0		0.0	180.0	0.0	0.0	0.0	0.0	0.0		
7	TA	61.5	1.8	59.7		1.8	59.7	0.0	0.0	0.0	0.0	0.0	0.97	L
	BA	100.0	20.0	80.0		20.0	80.0	0.0	0.0	0.0	0.0	0.0		
8	TA	84.8	15.8		69.0	84.8	0.0	0.0	0.0	0.0	0.0	0.0	0.00	O
	BA	80.0	20.0		60.0	80.0	0.0	0.0	0.0	0.0	0.0	0.0		

a Trees display no evidence of defoliation.
b Trees which display defoliation ranging from > 0 to < 25 percent defoliation of total needle complement.
c Trees which display defoliation ranging from ≥ 25 to < 75 percent defoliation of total needle complement.
d Trees which display defoliation ranging from ≥ 75 to < 90 percent defoliation of total needle complement.
e Trees which display defoliation ranging from ≥ 90 to 100 percent defoliation of total needle complement.
f Trees <9" d.b.h. which display defoliation ranging from ≥ 90 to 100 percent defoliation of total needle complement.
g Trees ≥9" d.b.h. which display defoliation ranging from ≥ 90 to 100 percent defoliation of total needle complement.
h Damage index = 0 (No/Total TA) + 1 (Light/Total TA) + 2 (Mod./Total TA) + 3 (Heavy/Total TA) + 4 (V. Heavy/Total TA).
i Damage Class O = 0.0, L = >0.0 - 1.00, M = >1.00 - 2.00, H = >2.00 - 2.80, VH = >2.80 - 4.00

Table 25.--Mean stocking levels for host trees greater than 5 inches d.b.h. by individual tree defoliation classes and number of trees per acre predicted to be top-killed within 4 years after initial defoliation in sample areas from Bogus Basin and Sunset Mountain, Boise National Forests, 1991.

Area	Line	Area Damage Class[a]	Individual Tree Defoliation Classes										Top-kill (Trees/AC)	
			DF (Trees/AC)					TF (Trees/AC)						
			0[b]	Light[c]	Mod.[d]	Heavy[e]	V. Heavy[f]	0	Light	Mod.	Heavy	V. Heavy	DF	TF
Bogus Basin														
	1	0	43.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sunset Mountain														
	1	L	0.0	17.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0
	2	0	29.0	0.0	0.0	0.0	0.0	125.8	0.0	0.0	0.0	0.0	0.0	0.0
	3	0	98.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	4	M	5.8	35.3	0.0	0.0	0.0	0.0	42.4	23.5	0.0	0.0	2.1	4.3
	5	0	24.3	0.0	0.0	0.0	0.0	3.6	0.0	0.0	0.0	0.0	0.0	0.0
	6	L	0.0	47.7	0.0	0.0	0.0	0.0	11.5	0.0	0.0	0.0	2.9	0.4
	7	L	1.8	0.0	0.0	0.0	0.0	0.0	59.7	0.0	0.0	0.0	0.0	1.8
	8	0	15.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

[a] Area defoliation class taken from the damage index column of table 24; 0 = no defoliation, L = light defoliation, M = moderate defoliation, H = heavy defoliation, VH = very heavy defoliation.

[b] 0 = no defoliation

[c] Light ranges from >0 to <25 percent defoliation of total needle complement.

[d] Mod. ranges from ≥25 to <75 percent defoliation of total needle complement.

[e] Heavy ranges from ≥75 to <90 percent defoliation of total needle complement.

[f] V. Heavy ranges from ≥90 to 100 percent defoliation of total needle complement.

Table 26.--Predicted early larval densities for 1992 based upon cocoon sampling conducted in 1991 from areas with no or only light defoliation on Bogus Basin and Sunset Mountain, Boise National Forest, 1991.

Area	Line	Actual 1991 cocoons/1000 sq. in.	Actual[a] Def. Class.	Predicted[b] 1992 larvae/1000 sq. in.	Predicted[c] Def. Class.
Bogus Basin					
	1	0.02	0	2.35	0
Sunset Mountain					
	1	0.88	L	57.30	H
	2	1.00	0	64.97	H
	3	0.54	0	35.58	L - M
	4	2.12	M	136.54	VH
	5	0.20	0	13.85	0
	6	1.34	L	86.70	H
	7	0.00	L	0.00	0
	8	0.02	0	2.35	0

[a] Area damage classes taken from Table 24.

[b] Predictions calculated from the regression equation, Y = 1.07 + 63.9 (X) where X = number of pupal cocoons per 1,000 square inches of foliage in 1991 and Y = number of early larvae per 1,000 square inches of foliage predicted in 1992.

[c] No defoliation, light to moderate defoliation, heavy defoliation and very heavy defoliation is predicted for 1992 when larval populations average <20 larvae, 20 to 49 larvae, 50 to 99 larvae, and >99 larvae per 1,000 square inches of foliage.

Table 27.--Mean stocking levels for host and non-host tree species greater than 5 inches d.b.h., stocking levels by defoliation class, stocking levels of precommercial- and commercial-sized trees in the very heavy defoliation class, area damage indices, and area damage classes for sampled areas on the Payette National Forest, 1991.

								Individual Tree Defoliation Classes					V. Heavy Class		Area Damage	
Area	Line		Total	DF	GF	SAF	S	Non-Host	No[a]	Light[b]	Mod.[c]	Heavy[d]	V. Heavy[e]	Pre-comm.[f]	Comm.[g]	Index[h]	Class[i]
Bear Creek																	
	13	TA	346.1	259.4				86.8	346.1	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0
		BA	200.0	140.0				60.0	200.0	0.0	0.0	0.0	0.0	0.0	0.0		
Blue Bunch																	
	12	TA	25.5	3.5	4.3			17.7	25.5	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0
		BA	80.0	20.0	20.0			40.0	80.0	0.0	0.0	0.0	0.0	0.0	0.0		
Brundage																	
	9	TA	410.3		144.4	29.8	127.4	108.7	410.3	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0
		BA	240.0		80.0	20.0	80.0	60.0	240.0	0.0	0.0	0.0	0.0	0.0	0.0		
Crooked River																	
	14	TA	153.7	115.5				38.2	153.7	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0
		BA	80.0	60.0				20.0	80.0	0.0	0.0	0.0	0.0	0.0	0.0		
Fall Creek																	
	10	TA	99.0	28.8	55.9			14.3	99.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0
		BA	80.0	40.0	20.0			20.0	80.0	0.0	0.0	0.0	0.0	0.0	0.0		
Filly Creek																	
	11	TA	61.3	23.0				38.3	61.3	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0
		BA	100.0	40.0				60.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0		
Mica Creek																	
	7	TA	61.7	9.5	52.3				61.7	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0
		BA	100.0	40.0	60.0				100.0	0.0	0.0	0.0	0.0	0.0	0.0		
Paddy Flat																	
	8	TA	204.2	100.6	26.3	22.7		54.5	107.8	96.4	0.0	0.0	0.0	0.0	0.0	0.47	L
		BA	100.0	40.0	20.0	20.0		20.0	40.0	60.0	0.0	0.0	0.0	0.0	0.0		

a Trees display no evidence of defoliation.
b Trees which display defoliation ranging from > 0 to < 25 percent defoliation of total needle complement.
c Trees which display defoliation ranging from ≥ 25 to < 75 percent defoliation of total needle complement.
d Trees which display defoliation ranging from ≥ 75 to < 90 percent defoliation of total needle complement.
e Trees which display defoliation ranging from ≥ 90 to 100 percent defoliation of total needle complement.
f Trees <9" d.b.h. which display defoliation ranging from ≥ 90 to 100 percent defoliation of total needle complement.
g Trees ≥9" d.b.h. which display defoliation ranging from ≥ 90 to 100 percent defoliation of total needle complement.
h Damage index = 0 (No/Total TA) + 1 (Light/Total TA) + 2 (Mod./Total TA) + 3 (Heavy/Total TA) + 4 (V. Heavy/Total TA).
i Damage Class 0 = 0.0, L = >0.0 - 1.00, M = >1.00 - 2.00, H = >2.00 - 2.80, VH = >2.80 - 4.00

Table 28.--Predicted early larval densities for 1992 based upon cocoon sampling conducted in 1991 from areas with no or only light defoliation on the Payette National Forest, 1991.

Area	Line	Actual 1991 cocoons/1000 sq. in.	Actual[a] Def. Class.	Predicted[b] 1992 larvae/1000 sq. in.	Predicted[c] Def. Class.
Bear Creek					
	13	0.00	0	0.00	0
Blue Bunch					
	12	0.00	0	0.00	0
Brundage					
	9	0.00	0	0.00	0
Crooked River					
	14	0.00	0	0.00	0
Fall Creek					
	10	0.00	0	0.00	0
Filly Creek					
	11	0.04	0	3.63	0
Mica Creek					
	7	0.00	0	0.00	0
Paddy Flat					
	8	0.00	0	0.00	0

[a] Area damage classes taken from Table 27.

[b] Predictions calculated from the regression equation, Y = 1.07 + 63.9 (X) where X = number of pupal cocoons per 1,000 square inches of foliage in 1991 and Y = number of early larvae per 1,000 square inches of foliage predicted in 1992.

[c] No defoliation, light to moderate defoliation, heavy defoliation and very heavy defoliation is predicted for 1992 when larval populations average <20 larvae, 20 to 49 larvae, 50 to 99 larvae, and >99 larvae per 1,000 square inches of foliage.